Evaluating the Impact of a Problem-Based Learning Curriculum on Undergraduate Medical Students in Saudi Arabia

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Ph D Thesis

University of Durham

2007

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A thesis submitted for the degree of

Doctor of Philosophy

(Medical Education)

at the

School of Education

University of Durham

United Kingdom

2007

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Abstract

The main aim of this study was to examine in detail the benefits and problems of introducing a different method of teaching to medical education, namely the problem-based learning (PBL) method. This technique, in a number of pieces of research, has been shown to be more effective than lecture-based method in fostering better critical-thinking, problem solving, and the self-directed learning skills of students, and also to enhance the acquisition and retention of knowledge. But PBL has not been universally successful. Despite this it has being recommended by medical educators worldwide; yet it remains to be formally evaluated in Saudi Arabia.

To evaluate the impact of PBL to students in particular and to Saudi Arabia in general, a test run of the method was carried out, in which four Saudi medical colleges were selected to participate. The total number of subjects was 484, comprising 232 pre-clinical students (Pre-CS) and 252 clinical students (CS) from five courses (units/modules) in the medical curriculum. A human genetics module was used as a case subject for the test run, and both pre-clinical and clinical students were assigned randomly to either a PBL or a lecture-based curriculum (LBC) group. Data was collected using six instruments which assessed knowledge, attitude, learning styles and perceptions of students in order to test fourteen hypotheses regarding the benefits of PBL to Saudi undergraduate medical students compared to LBC.

Both qualitative and quantitative methods were used to collect and analyze the data. Qualitative data included essay-type written response from students, which was analyzed using Nvivo. For the quantitative data analysis, several analytical procedures within SPSS were employed. These included descriptive and Chi-Squared Statistics, Univariate analysis, One-Way and Two-Way ANOVAs and Effect Size calculations.

From the randomized controlled trial undertaken on pre-clinical and clinical students, very large differences were found in the outcomes for the two groups. Within the pre-clinical students, those in the PBL group scored significantly lower than those in the LBC group on every indicator of perceived knowledge, learning or examination results. For the clinical students, those in the PBL group scored significantly higher than those in the LBC group; these positive effects of PBL did not include learning outcomes, however. Of the fourteen hypotheses stated, highlighting the benefits of the PBL approach to Saudi undergraduate medical students, none was supported with respect to pre-clinical students, while nine were supported with respect to clinical students. This brought out a large difference between Saudi Arabian pre-clinical and clinical students in response to the intervention of the PBL approach compared to the lecture-based teaching method. These quantitative findings were supported by the qualitative data.

Some of the central tenets of PBL are that it enhances knowledge retention, self-directed learning skills and level of motivation. These central tenets were not supported among Pre-CS; however, they were supported by results from CS. The use of PBL was associated with a change in motivating factors from purely self-achievement to the success of the group and shared knowledge.

The finding that PBL was significantly valued by CS but **not** by Pre-CS is discussed in relation to literature written about education and explained by drawing on the distinction between "transitional semi-PBL" (as experienced by the Pre-CS) and "rigorously problem-based learning" (as experienced by the CS).

This discussion leads to the proposal of an experiential-based learning model (PEBL), which is described in terms of its rationale, its major features and a means for its introduction into the colleges of medicine in Saudi Arabia.

Dedication

To my family

ACKNOWLEDGEMENTS

In the name of Allah the Most Compassionate and the Most Merciful, I am most grateful to God Almighty for the gifts of health, patience, guidance and protection throughout the duration of my study.

I would like to express my deepest thanks and sincere appreciation to those whose help has been instrumental to the outcome of this work. First of all, a special expression of gratitude is due to my supervisor Professor Peter Tymms. He directed me in the research process by helping me through the ideas and focuses of this study, encouraging and supporting me to go beyond my limitations. His relaxed and friendly style of supervision made him an exceptionally pleasant person to work with and, moreover, his ability to deal with such work made me feel confident about my research. So I am grateful to Professor Tymms for all his contributions in helping me to accomplish this study.

In the School of Education at Durham University, I would like to express my thanks to all faculty members and to Anita Shepherd for their help and support throughout my study.

Sincere thanks to King Faisal University, particularly to His Excellency, the President Professor Yousof Al Gindan, who have consistently and cheerfully supported me throughout my higher education studies. Also to the academic staff in the College of Medicine and College of Dentistry, and to every individual within the departments for their assistance and for offering me the chance to complete my study.

I owe a great debt of gratitude to my parents for their unconditional love and continuous support and prayers, which gave me the strength to go all the way. A special expression of love also to my brothers Eng, Khalifa, Basem and Jamal, and to my lovely sisters. Special thanks to my wife, who throughout the program has given me her understanding, encouragement and moral support, which have served as an inspiration for me to pursue my PhD program, and to my children, Feras, Elaf, and Muhannad, who sacrificed their pleasure for me to complete this research.

Lastly, I wish to convey my profound gratitude to all the persons who in one way or another have extended their support to the success of this endeavour.

DECLARATION

I declare that this thesis results entirely from my work and no portion of the work referred to in this study has been submitted in support of an application for another degree or qualification to this university or any other university or institution of learning.

STATEMENT OF COPYRIGHT

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LIST OF ABBREVIATIONS

AS	Attitude Survey
CBS	Cognitive Behaviour Survey
CM	College of Medicine
CPBL	Closed Problem-Based Learning
CS	Clinical Student
CEF	Course Evaluation Form
DQ	Demographic Questionnaire
FAMCO 409	Primary Health Care
GUE	Genetics Unit Examination
HBD	Human Biochemical Disorder
HCD	Human Chromosomal Disorder
HGU	Human Genetic Unit
HMD	Human Multifactorial Disorder
KAU	King Abdulaziz University
KFU	King Faisal University
KKU	King Khaled University
KSU	King Saud University
LBC	Lecture-Based Case
LBL	Lecture-Based Learning (traditional)
LI	Learning Issue
MCQ	Multiple Choice Question
MDOG 503	Obstetrics and Gynaecology
MDMD 451	Internal Medicine
MDMD 501	Internal Medicine
MDPA 306	General Pathology
MDPM 517	Clinical Pharmacology
MDPP 554	Paediatrics
MDPY 508	Psychiatry
MEQ	Multiple Essay Question
PEBL	Practice-Experiential-Based Learning

PB	Problem Brief
PBL	Problem-Based Learning
PreCS	Pre-Clinical Student
SCD	Student-Centred Discussion
SDC	Saudi Deans Council
SLOS	Student Learning Objective Sheet
SSCP	Student Suggested Clinical Plan
TEF	Tutor Evaluation Form
TJ	Triple Jump

DEFINITIONS

Definition of Terms

Certain words or phrases used in this study have specific and limited meanings. These include the following:

Problem- **(or** ***Practice-) based learning (PBL)*****:** This term refers to a very specific approach to education in medicine, supported by tools designed to facilitate a specific teaching-learning process. It is a rigorous, structured and student-centred approach to learning that results from the process of working towards the understanding or resolution of a patient problem, a health delivery problem or a medical research problem (Barrows & Tamblyn, 1980: 1, 10, 13). Originally termed "problem-based learning" by Barrows and Tamblyn (1980), the phrase "practice-based learning," has been introduced by Barrows (1994) to distinguish the use of the approach in medical education, and to remove an overemphasis on "problem" as a sole focus for appropriate medical education activities. A central feature of PBL is the role of faculty as generalists and facilitators (or tutors) (Adkinson & Volpe, 1994).

Lecture-based case (LBC): This term refers to an approach to medical education which has been characterized as teacher-centred and subject-based, with reliance on lectures as well as case studies, according to Barrows's (1986) taxonomy of PBL. The role of faculty in the traditional approach is that of experts.

Lecture-based learning (LBL): This term refers to an approach to medical education which has been characterized as teacher-centred and subject-based, with reliance on lectures only. The role of faculty in the traditional approach is that of experts.

Medical education: In the context of this work, this term refers to the specific components of post-secondary education responsible for the training of physicians.

In Saudi Arabia, where this research was conducted, this term refers to a six-year course of undergraduate study leading to a medical degree.

Pre-clinical education: For this research, pre-clinical education refers to the second two years of undergraduate coursework undertaken in Saudi Arabian medical schools, which is preparatory to entry into the final two years of clinical study. In some countries, preclinical education occurs in an undergraduate course of study referred to as the pre-medical (or "pre-med") curriculum, and is followed by four years of graduate-level medical school.

Clinical education: In this research, the term clinical education refers to the fifth and sixth years of Saudi Arabian medical education, which follow completion of preclinical coursework. Clinical education concludes with the receipt of a medical degree.

Human genetics: This term encompasses the diversity of disciplines that contribute to knowledge and understanding of the genetic, environmental, social and familial factors that interact to produce and control human variability. These include anthropology, psychology, the social sciences, and medicine (Davidson & Childs, 1987: 83).

Human genetics unit(s) (HGU): A human genetics unit is a part of the medical school curriculum which focuses exclusively, or almost exclusively, on educating students about a specific topic in genetics. A human genetics unit may be organized to teach about a specific genetic disorder or group of disorders, about community health aspects of genetic diseases, or with some other well-defined aspect of medical practice having a genetic foundation. Usually HGUs have specific objectives, defined in terms of student learning outcomes. In this research, HGUs will be presented as a unit offering a variety of subjects in the undergraduate medical curriculum at medical colleges.

Key Terms: Undergraduate medical education, Saudi Arabia, Problem-Based Learning, Curriculum, and evaluation.

Section I: Context and Aim of the Study

Chapter One

Context of the Study: Saudi Arabia and its Medical Education

Chapter One

Context of the Study: Saudi Arabia and its Medical Education

1.1 Introduction

> "Saudi Arabia needs the characteristics of modern man who is ready for new experience, accepts changes and looks towards the future more than the past or present. He should believe in education and technology and his own ability to improve himself" (Al-Khazim, 2003:23).

The Kingdom of Saudi Arabia is an independent country and was established in 1932, after King Abdulaziz Ibn Saud succeeded in capturing Riyadh (1902). Saudi Arabia (shown in white on the map below) is located in South-West Asia and comprises the bulk of what is commonly known as the Arabian Peninsula, bordering both the Red Sea and the Arabian Gulf, with the Suez Canal to the North-West border and the Indian Ocean to the South (figure 1.1).

Figure 1.1 Map of Saudi Arabia (Merriam-Webster Atlas, 2007)

As described by Long (1997:9),

> "Saudi Arabia is a country of startling contrast: a huge land mass with a small population; a barren desert terrain situated over great oil wealth; a traditional Islamic society undergoing rapid modernization; a closed society that is often in the news. The Saudis are deeply religious, traditionally conservative, proud people who have been forced to make the transition from the pre-industrial to the modern age in less than two generations. Under the country's arid surface lie roughly 260 billion barrels of oil – about one-quarter of the world's proved oil reserves, and most of it for export. Saudi society is thoroughly Islamic and places great importance upon the extended family, ultimately valuing bloodlines over oil wealth."

1.2 Population

The majority of Saudi Arabia's population is ethnically Arab, although there are small ethnic minorities originating from countries such as Indonesia, Africa, India and Turkey. Saudi-Arabians are considered to be extremely conservative, and follow Sharia law (Bureau of Near Eastern Affairs 2001).

The last census in Saudi Arabia was conducted in 1999 with the aim of updating the demographic database, in order to aid the work of the Ministry of Planning and other researchers and to meet development plan requirements. According to the Ministry of Planning (1999:495), in 1999 the total population across the country's thirteen administrative areas numbered 19,895,232.

The population of Saudi Arabia is growing at a rate of 3.5% annually. Growth has been particularly significant in and around cities and towns, which have become the undoubted leaders in the country's commercial, political, cultural and religious arenas. This rapid economic and urban growth has meant that, whilst the majority of the population was nomadic or semi-nomadic until the 1960s, today almost 95% of the population is sedentary. For years, population growth has been placing significant demand on Saudi Arabia's education system, which we will come to later.

1.3 Religion

The Kingdom of Saudi Arabia has always been of great importance for the world's Muslims, because here their two holiest cities are located: the Holy City of Makkah, containing the Ka'ba, birthplace of the Prophet Muhammad and home of Islam's most important shrine; and the Holy City of Madinah, where the Prophet established his first community and laid the foundations of Islam (these cities can be found on the map in figure 1.1).

The state religion of Saudi Arabia is Islam, and the Holy Quran forms the constitution. Islam permeates every aspect of a Saudi Muslim's life and, moreover, every aspect of the Saudi Arabian state; an understanding of this is essential before one may attempt to truly understand the Kingdom's history and its political, economic, educational and social development (Mutabbakani, 1993).

Indeed, the assertion of Cameron et al. (1983:755) almost 25 years ago remains true today:

> "Saudi Arabia is the heartland of Islam, the guardian of the Holy places; and nowhere is the influence of religion felt more directly or explicitly. Theoretically, religion and the state are one, and the Saudi constitution is the Quran. The law is Sharia (the totality of the religious and moral laws of Islam) law and the principal school adhered to is the Hanbali School, although the other three main Law Schools of Islam are also recognized and respected."

1.4 Economy

Saudi Arabia harbours approximately 25% of the world's oil reserves, as well as the fifth largest gas reserve in the world. Cautious planning within the Saudi government, through a number of five-year development plans, has brought great strength to the Saudi economy (Muttabbakani, 1993); yet this wealth has not been sufficient to ensure further economic development. Indeed, in the decade after the Gulf War of 1991, Saudi economic growth was slow. As Cordesman (2001b:9) has shown,

> "The data indicated that the Saudi economy grew by 9.5 % in real terms between 1969 and 1974, by 15.5 % between 1974 and 1979, but then dropped to 6.5 % between 1979 and 1984. There was virtually no real growth between 1985 and 1989.

The sudden rise in Saudi oil revenues caused by the Gulf War led to a 3.4 % rise in 1990 and a 6.0 % rise in 1991. Growth then averaged about one percent annually between 1993 and 1999."

To lessen the country's dependence upon oil, the Saudi government has for a decade promoted heavy industries (Janin, 1994), establishing two industrial cities consisting of huge numbers of factories for the manufacturing and petrochemical industries. These are situated in Jubail, on the east coast, and Yanbu on the west coast.

The economic development of Saudi Arabia has affected all aspects of life in the country. Greater educational opportunity has meant a huge increase in the number of both male and female students; standards of living have been rising, and social norms changing, causing a sometimes unconscious reconsideration of traditional values such as loyalty to relatives and fidelity to tribal leaders. As a result of economic strength and improvements in education, coupled with modernization and improvements in services such as the security forces, a middle class has emerged within Saudi society (Heller and Safran, 1985).

The speed and pressure of economic changes creates new challenges and stresses for educators. The pressure of increased demand on education at all levels, due to both demographic and socio-cultural factors, means that new ways have to be found to meet educational need.

1.5 Social change in Saudi Arabia

Saudi society is considered to be unique in having been transformed from a very poor to a very rich society in a period of time as short as thirty years. The impact of change in all aspects of life has received increased scrutiny in the last few years, and it has emerged that some, such as Adams (1986) and Al-Farsy (1990), consider the socio-cultural transformation of Saudi Arabia to have resulted directly from the pressure of western modernization. Yet despite these changes, most Saudi people remain conservative and religious, in accordance with instructions within Islam that are tightly embedded in society, culture and customs.

This interplay of tradition and change, and the emergence of new social groups within the society, are defining features of Saudi Arabia – and at the centre of it all is education. What values should govern it? How should it be made available? If education itself is a catalyst for change, how will it affect the social structure of Saudi society? Indeed, in the view of societal changes and with the advent of new learning methods, Saudi Arabia is now in a position to achieve an educational revolution; which form that revolution will take, however, is still unclear.

1.6 The education system in Saudi Arabia

Education in Saudi Arabia began formally in 1924 and has since been firmly under state control. In 1953, the government established the Ministry of Education, in charge of boys' education; in 1960, the Presidency of Girls' Education was established. This arranged study programmes and a syllabus for the education of girls so as to give them a clear understanding of their responsibilities towards their children, their home and society, whilst simultaneously satisfying the need felt in Saudi Arabia for highly trained women in education, health, banking and elsewhere. Fifteen years later, in 1975, the Ministry of Higher Education was established to supervise and control the universities in Saudi Arabia (whilst higher education institutions had already been operating before 1975, they had not previously come together under a formal ministry overseeing them).

1.6.1 Principles and characteristics of the education system

Saudi Arabia's education system follows Islamic philosophy. As stated by the Ministry of Education (1986:13), the main principles and aims of the education system in Saudi Arabia are as follows:

1. "Belief in Allah as the only God, Islam as the religion and Muhammad (may peace be upon him) as God's Apostle and messenger.
2. A totally Islamic concept of life, the Universe and of mankind.
3. Seeking knowledge is the obligation of each individual, and it is the duty of the state to provide and spread education.
4. Recognizing women's rights to obtain a suitable education on an equal footing with men in the light of Islamic laws.
5. Relating all stages of education to the State's general development plan.

6. Conscious interaction with international development in cultural fields.
7. Using Arabic as the language of instruction at all stages.
8. Encouraging and promoting the spirit of scientific thinking and research."

It is clear from the above that education in Saudi Arabia, in all its aspects, stages and organisations, is designed to support Islamic principles and objectives. The government is the main body responsible for education, and offers tuition and text books free to all citizens and residents at all stages of the education system.

1.6.2 Types of education in Saudi Arabia

The education system in Saudi Arabia consists of religious education (taught both formally and informally), higher education (associated with universities and colleges) and general education. In all Saudi Arabian educational institutions, including schools of medicine, males and females are educated separately.

1.6.2.1 The education of boys

The Ministry of Education is one of the most important ministries in the country, and has made significant progress. Having started with only a few schools, it now controls 5831 elementary schools, 3008 intermediate schools and 1466 secondary schools for boys alone (Ministry of Planning, 1999). According to the Ministry of Education (2002), the stages of the general education system for both sexes are as follows:

The stages of the general education system:

a. Six years of elementary school
b. Three years of intermediate school
c. Three years of secondary school

1.6.2.2 The education of girls

Before 1960, education was almost non-existent for girls in Saudi Arabia, and although the formal education of girls was established with the creation of the General Presidency for Girls' Education in 1960, ten years later there were only 15 elementary schools for girls in the whole of Saudi Arabia, and the education of girls remained controlled by common religious attitudes (Hammad, 1973). By 1999, however, the number of elementary schools had risen to 5705, with 2460 intermediate and 1384 secondary schools for girls (The Ministry of Planning, 1999:55-61). Then in 2002, the General Presidency for Girls' Education merged into the Ministry of Education, which was renamed the Ministry of Education and Learning (Ministry of Education, 2002:9).

1.6.2.3 Higher education

Higher education in Saudi Arabia was non-existent before 1949. The first institution of higher education in Saudi Arabia was the Sharia (Islamic law), established in 1949 in the Holy City of Makkah. In 1975, the Ministry of Higher Education was established to supervise the implementation of the Kingdom's policy in this field. Now, it supervises thirteen major Universities, found in major cities and towns as follows in table 1.1 (Al-Khazim, 2006).

Table 1.1 Number of students in Saudi universities

No.	University or College	Location	Year Established	Number of Students
1	Islamic University (IU)	Al-Madinah Al- Monawarah	1949	6513
2	Imam Muhammed Bin Saud Islamic University (IMSU)	Riyadh	1953	35081
3	King Saud University (KSU)	Riyadh	1992	51861
4	King Abdulaziz University (KAU)	Jeddah	1975	42741
5	King Faisal University (KFU)	Dammam	1975	12832
6	King Fahad University of Petroleum & Minerals (KFUPM)	Dhahran	1970	9639
7	King Khaled University (KKU)	Abha	1980	16966
8	University of Umm Al-Qura	Mecca	1980	24353
9	University of Qasim	Qasim	2002	500
10	University of Taiba	Al Madinah Al Monawarah	2002	450
11	University of Hail	Hail	2005	None yet
12	University of Jezan	Jezan	2003	400
13	University of Jouf	Jouf	2005	None yet

Statistics according to the Arab Political Magazine Online in 2001 showed that there were:

> "20,000 members of teaching staff at eight universities which are located in different parts of the country, teachers training colleges and technical and health colleges. The number of university colleges now amounts to 72" (Ain-Al-Yaqeen)

Since 2001, as can be seen in table 1.1, five more universities have been established in Saudi Arabia.

According to Al-Ankary (1998), Minister of Higher Education in Saudi Arabia, Saudi higher education policy is as follows:

1. All citizens in Saudi Arabia are to get the same opportunities in higher education, without any discrimination, according to the individual's potential and actual abilities.
2. Universities and colleges will concentrate on scientific research in all fields, whether theoretical or applied. This improves work carried out in the social services, research and publication.
3. Both male and female students in Saudi Arabia have the opportunity to continue their higher education without charge, in all subjects and at all levels.
4. The Saudi government's aim is to evaluate higher education and its contribution to every stage of the country's development.
5. Higher institutes and universities are to use available methodologies for the evaluation of programmes, administration and equipment in order to continue achieving top results in scientific research.

Most of the faculty staff in Saudi Arabian universities received their degrees from Western countries, such as the United States, the United Kingdom, Germany, and France, and are keen to promote the modernization of their society while maintaining the Islamic religion and Saudi traditions.

1.6.3 Major problems faced by higher education in Saudi Arabia

As a result of demographic changes, higher education in Saudi Arabia is currently encountering a very serious problem: the increasing number of secondary school graduates who wish to continue their education. If universities and other higher education institutions absorb too large a number of students, implications upon university resources may eventually lead to poorer quality graduates in some subject areas (Al-Khazim, 2006).

As shown by the 8th Five-Year Development Plan (2005-2009), to solve this problem the government opened ten universities and a number of community colleges in various Saudi Arabian cities (Jizan, Hail, Tabuk and Hafralbatin). Further proposals and solutions to this problem have evolved through the intensive efforts of both public and private sector organisations to establish new higher institutions (Ministry of Planning, 2005).

These private universities concentrate on the medical and health sciences and are intended to absorb the large numbers of school leavers who cannot find places in state universities. They are intended to keep Saudi students in the country, for too many have sought education abroad in other Middle Eastern countries. Saudi Arabian universities now absorb a significant two thirds of secondary school graduates (Ministry of Planning, 2005).

Deciding to train as a doctor has become a respectable and prestigious career choice (Al-Sibai, et al., 1989). There is considerable demand upon secondary school graduates to be admitted into one of the Colleges of Medicine in Saudi Arabia, and extreme competition for places. Admission requirements include secondary school marks, entrance examinations in the sciences and in English, and an interview, following which students are admitted depending on the number of points thus accumulated.

1.7 The colleges of medicine in Saudi Arabia

Research for this study was conducted at Saudi Arabia's four oldest colleges of medicine: King Saud University (KSU) Medical College, established in 1969; King Faisal University (KFU) Medical College (1975); King Abdulaziz University (KAU) Medical College (1975); and King Khaled University Medical College, established in 1982 (Al-Khazim, 2006). These were chosen for research purposes to represent medical education in Saudi Arabia because they are the oldest and have produced the most graduates.

Since 2002 a further nine colleges have been established and these are: Umm-Ul Qura (Mecca), Taif City and Taiba (Madinah city) in the western region; Al-Qasim, King Saud for Health Sciences (Riyadh) and King Fahd Medical College (Riyadh) in the central region; Hail in the north-eastern region; King Faisal (Al-Hassa) in the eastern region; and Najran (Jezan) in the southern region (Al-Khazim, 2006).

The colleges of medicine are in addition to eleven other universities and higher education institutions, which serve more than 2.5 million students in Saudi Arabia each year. In 2005, the colleges of medicine received in total more than 4,950 students and were served by 829 faculty members with a student: staff ratio of 12:1. In addition, approximately 1,021 students enrolled at colleges of medicine, of which 492 were male and 529 female. Since 1969, a total of 4,550 students have graduated from higher education, 3,330 of these male and 1,220 female (Al-Khazim, 2006).

Currently in Saudi Arabia, all medical schools use LBL as their curricular system. This traditional and teacher-centred (Harden, 1986) curricular system has been adopted, based on the experience and documented literature of the UK and USA, since the first medical school was established in Saudi Arabia in 1969 (Al-Khazim, 2003).

Yet LBL curricula have not always produced satisfactory results. Acknowledgement as such and investigation into the matter led to revisions of the medical curriculum in Saudi Arabia, which are described in section 1.8.

1.8 Revision and evaluation of the existing medical curriculum in Saudi Arabia

1.8.1 The first revision (El-Mouzan et al., 1991:4)

Premedical examination results for the first two classes (1981 and 1982) showed a 70% failure rate in some subjects, calling for a review of all aspects of the curriculum. Several committees were assigned to this task, interviewing individual students, faculty members and department heads. It was found that English language proficiency among the students was below the required standard, and that time assigned to premedical and basic science courses was not adequate to cover material that students needed for a good understanding of preclinical and clinical subjects. As a result, the subsequently revised curriculum placed more emphasis on English proficiency, physics and biology.

However, the more important change in the curriculum was the replacement of the annual system with the credit hour/semester system, allowing different students to proceed at different paces, according to their abilities. With supervision and advice from faculty members, each student could now register for an appropriate course load, varying within specified upper and lower limits, with each student required to maintain a cumulative grade average equivalent to about 65%. This system allowed candidates the flexibility to graduate within either 7, 8, 9 or 10 years of beginning their medical studies, the importance being placed on good results rather than on course length.

For a curriculum to produce good results, it must be followed by high-quality students and high-quality faculties. Therefore, the schools of medicine looked carefully at both students and faculties that had not been producing good results and then established appropriate selection systems for student admission and faculty appointment, encouraging ongoing assessment. As a result, student performance improved, with a drop in failure rate from 20% to 15%.

This revised curriculum was followed for 5 years before the call for yet another review became necessary.

1.8.2 The second revision (Al-Awdah et al., 1994)

The need for a second revision was triggered mainly by the clinical faculty and, to some extent, by the students themselves, for the following reasons:

1. The time assigned to clinical and preclinical subjects was not well balanced; the latter were getting more time at the expense of the former.
2. The subject load in the basic sciences and pre-clinical stages was distributed unevenly.
3. New courses were needed to keep up with recent trends in medical education.

4. There was a need to eliminate as much as possible unnecessary repetition and duplication, which then existed between some courses.
5. Prerequisites were in many cases unrealistic and obstructive to students' registration for even the minimum required subject load.

Several subcommittees were formed in order to take a closer look at the issues raised. Each subcommittee consisted of faculty members representing departments offering closely-related courses, and was expected to assess the problems in order to determine the needs and work backwards.

The subcommittees identified what a practicing physician should be able to do competently at the end of the student training and, on this basis, decided what should be included in the premedical basic sciences and pre-clinical courses. In particular, each committee was requested to ensure that contents were relevant to course objectives and that the latter eliminated unnecessary repetition and allocated time thus saved to strengthen the curriculum. The committees then submitted plans and proposals for improvement of the curriculum.

Feedback from final year students and interns was obtained through an open-ended anonymous questionnaire, in which each candidate was required to give honest views on the following items:

1. Year(s) with overcrowding of courses
2. Courses not appropriate to the medical curriculum
3. Courses assigned more contact hours than necessary
4. Courses that needed more time in order to be covered adequately
5. Courses that contained similar subject matter, resulting in unnecessary repetition
6. Courses that needed to be added to the curriculum
7. Courses that needed to be deleted

Results indicated a need to reduce the time previously assigned to premedical basic sciences and preclinical subjects by the equivalent of nearly one full semester, which was then dedicated to clinical subjects. The distribution of the course load over the semesters became more even, and prerequisites for subject registration were reduced to those absolutely required.

The new curriculum offered a good spectrum of electives, each of whose objectives and content were revised in order to ensure relevance to medical practice. The curriculum retained its duration of 6 years plus a year's internship, modifying the latter to include one compulsory month of primary healthcare, leaving one month for an elective. The total number of credit hours in the new curriculum was 228, as opposed to the 254 of the previous curriculum, students benefiting from time saved for private study.

In the pre-clinical phase, successful completion of all courses was emphasized as a necessary prerequisite to the clinical phase.

1.8.3 **The third revision** (Al-Muhanna, 2000)

Despite the measures taken to improve students' results, it became obvious that many of them were unable to attain the minimum required grade average. Consequently, this required average was reduced to just 40%; but even that did not help all students. Curriculum planners noted that students were taking the minimum possible course load without utilizing their free time appropriately, thus prolonging their stay in the college unnecessarily.

As a result, the curriculum was revised for the third time. Courses were again adjusted, with appropriate deletions, additions and augmentations. The semester became based on days instead of hours, and evaluation became based on the whole year's work instead of on termly exams. Furthermore, students who failed in a subject could take a resit examination in the summer without repeating the course as had been previously required.

1.8.4 **The fourth revision** (Al-Muhanna & Lutfi, 2002)

The fourth revision of the medical education curriculum came in late 1999, confirming the idea of curriculum reform as a continuous process. The curriculum committee of Medical Colleges in Saudi Arabia once again modified courses and adjusted contact time. After this reform, six guidelines were formulated which unified all Medical Schools.

1.8.5 What do the revisions of the Saudi undergraduate curriculum show?

It is interesting to note that the curriculum is similar to that of other Medical Schools throughout the world, and shares many of the same problems (Lowery, 1993:77-80).

These four revisions in many ways broke substantially from the LBL pattern. There is still, however, a major case for suggesting that medical education in Saudi Arabia is somewhat problematic educationally, but from the available evidence it is unclear precisely what the cause of the problem is. It seems likely that the problem is located in the premedical, basic sciences and preclinical years, which is particularly problematic since it is during this time that most of the theoretical teaching occurs and students first begin to use their knowledge in a theoretical setting.

Each of the studies reported has criticized the preclinical phase most severely, largely due to the poorly managed transition between the pre-clinical and clinical phases.

In the light of this, it would seem reasonable to ask the following questions:

- What is the alternative choice for medical education in Saudi society?
- Is the Saudi student learning differently in the light of recent changes to culture and traditional values?
- Will institutions accept a continued process of change to the curriculum?
- How easy is it for them to do this?
- Is it right to apply a unified curriculum to Medical Colleges located in different regions of Saudi Arabia?

1.9 Summary

This chapter has set out a history of education and, more specifically, medical education in Saudi Arabia, in the context of the country's economy and its changing demography, culture and societal values. The traditional lecture-based approach to medical education was explained, followed by a description of the four curriculum revisions that occurred in Saudi medical education between 1990 and 2002.

It appears that another revision of the curriculum is now needed, this time in order to link together the various phases of the curriculum, so that knowledge from lecture-based theoretical teaching may be successfully brought into the clinical phases through improved retention of knowledge that allows what has been learnt to be applied in practical settings. It is also clear that these teachings need to be more applicable to a changing society in order to ensure that future physicians can effectively fulfil their role within that society.

This thesis will aim to review new teaching methods and to investigate how they might be applicable to the Saudi undergraduate medical curriculum. The specific aims and objectives of the study will be outlined in the following chapter before a comprehensive review of alternative teaching methods and their successes is examined.

Section I: Context and Aim of the Study

Chapter Two

The Aims of the Study

Chapter Two
The Aims of the Study

2.1 Introduction

Medical education, the focus of this study, constitutes the training of health care professionals and is a popular career choice all over the world. Medical students become highly qualified, well motivated and respected, which unsurprisingly leads to a high level of competition for places on medical courses (Thomas, 1997). Medical science and therefore its education is continually evolving, incorporating cutting-edge technology and making it one of the more expensive forms of higher education (Lowery, 1993; Al-Gendan, 1998). Due to this, the fundamentals of teaching medicine, alongside its curriculum must also be continually reviewed in order that it remains up to date.

Undergraduate medical education within Saudi Arabia has been nationally established since 1969, and since this time a small amount of literature has been collected and reviewed which indicates that the LBL (Lecture-Based Learning) approach to teaching has not always proved successful (Coles, 1985a). Using this technique students have become overloaded with the substantial amounts of information they need to learn and process (Kassimi, 1983; Coles, 1995), and fail to see the relevance of what they are being taught (Salvatori, 2000). A number of students lose motivation (Botelho, 1990; Mann et al., 1999) and find the transition between pre-clinical and clinical medicine demanding, becoming unable to recall and apply techniques they have previously learned (Azer, 2001; Al-Shehri, 2001).

Within the past three decades a number of alternatives to the LBL method of teaching medical education have begun to emerge (Barrows & Tamblyn, 1980). One of the most popular of these techniques is called Problem-Based Learning, or PBL. This approach to teaching the medical curriculum has been used in North America, Europe, Middle East and Asia (Kufman, 1996), and within these areas it became so successful that it has been adopted by more than one hundred medical schools throughout the world (Jayawickramarajah, 1996).

In response to this, a number of questions need to be asked of the heavily-criticized undergraduate curriculum in Saudi Arabia's medical schools (Al-Umran, 1996; Al-Shehri, 2001):

- Is there a need for change within the Saudi medical curriculum for the reasons mentioned above?
- Can Saudi medical schools and their students adopt PBL?
- Are the outcomes expected of the learner in a PBL setting applicable to students from different cultural upbringings?

The leaders of Saudi medical education want to know the causes behind the problems associated with the undergraduate curriculum and whether the various alternatives are worthwhile (Milaat and El-Gamal, 1994; Al-Shehri, 2001). Do PBL curricula alleviate these problems, and is it really true that students learn what they need to know more effectively and efficiently as a result of one curriculum arrangement over another?

PBL has been recommended by medical educators worldwide but has not been formally evaluated in Saudi Arabia. This study aims to evaluate the experimental introduction of PBL to undergraduate medical education in Saudi Arabia, using a module on human genetics as a case study. To accomplish this, an in-depth study of the PBL curriculum approach will be conducted, whilst investigating the most efficient and effective ways of implementing a PBL curriculum.

2.2 Significance of the study

2.2.1 Problems associated with the Lecture-Based Learning (LBL) curriculum in medical colleges in Saudi Arabia

The Kingdom of Saudi Arabia has made medical education a high priority (El-Hazmi, 1996). As mentioned in Chapter One, in Saudi Arabia there are at present ten colleges of medicine within thirteen universities.

Medical colleges located in Saudi Arabia present a curriculum where LBL has been used as a teaching method for the past three decades (Al-Muhanna, 2000). The undergraduate medical curriculum is identical in all colleges and takes six years to complete. High school students are required to meet admission pre-requisites before being accepted onto the course at the age of 18. The curriculum has been divided into four stages as follows:

Stage 1: Pre-medical Phase
Stage 2: Basic Sciences
Stage 3: Pre-clinical Phase
Stage 4: Clinical Phase.

Upon successful completion of the course, students graduate with an MBBS (Bachelor of Medicine and Surgery) degree, after which they are obliged to complete a compulsory internship programme for a period of no less than one year. Instructional methods include lectures, tutorials and practical sessions. Student evaluation is based on continuous assessments throughout each semester, in the form of written / practical work and oral examinations, as well as on the final examination, which is split into written, practical and oral sections and includes multiple choice questions, true or false questions and short- and long-answer essays (Al-Sibai et al. 1989)).

During recent years, several problems were noticed in relation to LBL, and these are summarized below. It is thought that these problems could have an adverse affects on the students' performance (El-Muzan et al., 1990; Al-Awdah et al., 1994; El-Hazmi et al., 1996; Al-Muhanna, 2000).

Problems in the traditional curriculum include:

- The undergraduate curriculum has a factual overload of knowledge.
- Students have difficulty with conceptual 'thinking in English'.
- LBL lacks integration and synchronization of the preclinical subjects with the clinical sciences.

- Students rely heavily on gaining the required information through lectures, and the ability to direct one's own study habits independently is not sufficiently addressed.
- It has been noticed that there is too much compartmentalization of the student's knowledge and too little integration throughout the curriculum. The curriculum setup relies heavily on a hospital setting, rather than involving problems of community disease.

The question to be asked is this: Is it the right time for Saudi medical education to face these problems and change in order to meet the needs of both the students and the community?

2.2.2 Are Saudi medical schools currently ready for a change?

> "Saudi Universities have to take on the role of training our students in self-learning and the research of information, and investing this into a solution to the Saudi community problem" (Al-Khazim, 2006: 59).

In addition, several national reports – mainly from educators within Saudi's medical colleges – have addressed the need for a re-evaluation of the existing medical curriculum. As Al-Gendan et al. (1998:230) states:

> "Several surveys were carried out in the college of medicine at King Faisal University to see if any form of change was needed and to examine some of the local trends. The study also showed that more than 70 % of the surveyed faculty supported some form of change."

At the First Scientific Conference of the Monarch of Medical Education in Saudi Arabia in 2004, the Ministry of Higher Education stated: "It is time to implement the innovative experiences on medical education and curriculum development" (Al-Riyadh Newspaper, 2004).

Chapter One mentioned the various ongoing curricular evaluations and modifications in Saudi medical education. PBL has not yet reached Saudi Arabia, but has been tested by some schools elsewhere in the Middle East. Generally, very few medical schools in the Middle East are accepting PBL techniques, but there are some – Gezira and Juba in Sudan (Magzoub, 1993), the College of Medicine and Medical Sciences of the Arabian Gulf University (Jayawickramaragh 1996), and the Suez Canal University, Ismailia, Egypt (Refaat and Nooman, 1989), for example – which are considered among the pioneers of PBL teaching methods. Within these colleges, the PBL approach had as its primary goal the alignment of medical training programmes with the health needs of their respective communities.

A review of the curriculum can be dictated by the social, cultural, demographic and economic changes that have taken place in society and, with these changes in mind, ways in which the current curriculum is deficient can be identified. According to Al-Gindan et al. (1998), Saudi universities and colleges should be willing to significantly change their own character as a reflection of the change in the character of those for whom they exist. Yet Al-Gindan et al. (2000) thought the action and reaction process to be slower between universities and society in Saudi Arabia at than was the case in other countries.

Al-Kuwaiti (2007) found ten publications addressing changing issues and emphasizing problems related to the curriculum in the Saudi Medical colleges. These ten publications uniformly agreed on the existence of problems within the current curricula, including problems of an overcrowded curriculum, overrepresentation of some subjects, and dissociation between basic and clinical sciences. All of these factors are to some extent behind recent changes in Saudi medical colleges.

Having looked the Saudi curriculum through, Al-Gindan et al. (1998:229) decided:

> "Many scientific, socioeconomic and regional changes have prompted the examination of the curriculum in medical schools. Some faculty members considered the curriculum obsolete and thought that it needed fundamental changes that should include not only course content but also course objectives, duration, teaching methodology and evaluation methods. Though the objectives were appropriate they required some change in the course contents with the introduction of newer subjects and omission of older non-utility subjects."

Saudi Medical Colleges need to change their curriculum to incorporate some of the new methods and approaches. But it would not be right to simply leave behind their previous developments and educational tools. Instead, each medical college should look at the strategies suggested and decide which could be appropriately adopted. Is it possible to adopt a community-based approach and at the same time keep a teacher-centred curriculum? Is it possible to introduce PBL whilst maintaining a discipline-based approach?

It is time for the kind of changes that have been internationally adopted and nationally requested as well as recommended. In which ways can we begin to make changes within medical colleges in Saudi Arabia? Which methods can we adopt in order to achieve the purposes of education?

2.2.3 The relation of Saudi medical schools to the needs of the community

The main objective of medical schools is to provide a society with competent physicians who are aware of societal needs and of practices within the realms of medical ethics. As Al-Umran (1996:10) highlights, "medical education must be responsive to the changing needs of the community it seeks to serve in the field of undergraduate teaching." Al-Mulhim and Al-Kuwaiti (2002:55) also emphasize that "with the increase of immigrant population, the advent of new diseases and medical problems we need to have a revision of the medical curriculum accordingly."

However, Al-Sebai et al. (1982:3) note that traditional curricula do not always allow medical schools to meet this objective:

> "A gap has developed between the training provided for physicians and the real health needs of many countries. Throughout the Middle East infectious diseases and malnutrition, etc., are the major factors which cause health problems. Traditional medical schools follow curricula which do not prepare their graduates for these problems."

In addition, the curriculum stresses clinical subjects at the expense of medical vocational skills; the part devoted to psychiatry and psychology is too formal; and courses on communication skills and attitude are often insufficient or lacking. Some subjects, including medical ethics, economics and information technology, have still not been introduced in some Saudi medical colleges (Al-Kuwaiti, 2007).

Can health care for the community be achieved through medical education? Which subjects need to be developed in the curriculum so as to train doctors for the fulfilment of community needs? Does each country have health problems particular to itself that must be emphasized by medical curriculum? How are methods of teaching medicine related to the needs of the community?

A case study involving the instruction of human genetics will be used in order to answer some of these and previous questions.

2.2.4 Why was Human Genetics chosen as a case study?

The subject of human genetics deals with biological development and variation through the life cycle (Graham et al., 1989), and its principles are considered fundamental to both biology and medicine (Wright, 1958; Childs, 1990).

In the past, the fields of epidemiology, obstetrics, paediatrics and public health in medical practice have been those which most obviously incorporated and reflected developments in genetics. It is of particular relevance for this work, however, that recent discoveries and advances in molecular technology – most notably recombinant DNA technology – have begun to provide genetics with tools to begin understanding human disease within all medical subspecialties and across all age groups. As Nooruddin et al. (2004: 1181) states, "as each of these medical specialties begins to integrate this emerging technology, the field of human genetics clearly has the potential to provide a paradigm for medical education as a whole."

Following a ten-year study conducted for the London-based General Medical Council Education Committee, Davidson (1988) outlines major deficiencies in the teaching of genetics in a number of UK medical schools. Following this, Harris et al. (1990:750) conducted a survey of teachers in Britain's 28 medical schools, finding likewise that "the teaching of genetics was variable [in the UK]." Harris states that "teaching was given by many departments and was generally of unknown quality or clinical relevance."

On the basis of the full findings of Harris's survey, the British Royal College of Physicians formulated a series of specific recommendations, advising more curricular content on genetics in both clinical and pre-clinical medical education courses. They also recommended greater involvement of clinical geneticists in teaching and in curriculum coordination.

Investigations into genetics instruction in North America and the United Kingdom were to a large extent driven forward by the Report of the Task Force on Teaching Human Genetics in North American Medical Schools. This Task Force was convened by the Information and Education Committee of the American Society of Human Genetics (ASHG) and charged with the responsibility of examining the "challenge of teaching human genetics in medical schools and reporting back to the ASHG Board of Directors with recommendations as to how the ASHG might improve this teaching" (Graham et al., 2004: 1181-1182). The issues considered by the Task Force were shaped by a report by Riccardi and Schmickel, published in 1988, as well as by the guidelines of the Association of American Medical Colleges (AAMC, 1984: 20-22). The curriculum issues related to LBL, as identified by the ASHG Task Force, included:

1. A lack of human genetics teaching resources in many medical schools.
2. The need for vertical integration of human genetics teaching through all four years of medical school.
3. Competition for student contact hours in a setting of decreasing lecture hours and increasing need for small-group interactions.
4. A need for appropriate evaluation techniques.
5. Identification of faculty experts and materials.
6. Identification of a minimum core curriculum.
7. Identification of implementation strategies.

Most importantly, the question to be answered is this:

- Is information about human genetics communicated effectively to pre-clinical and clinical students enrolled in LBL world-wide?

Unfortunately, little data exists upon which to base a response. Assessments of the specific information on human genetics included in the medical curricula and of the methodologies being employed to communicate this information are scarce, particularly outside Western cultures. Evaluations of how genetics training is used by medical practitioners, or how successfully particular teaching methodologies are being employed to convey this information within medical curricula individually are even less numerous.

Saudi Arabia is a country with a large number of genetically-related diseases, due at least in part to the homogeneity of the population and cultural tradition as in marriage that will enhance the probability of hereditary disorders (El Hazmi, 1993). Yet the current medical curriculum has failed to introduce the teaching of human genetics or to increase awareness of the relevance of the subject to society (El Hazmi, 1993). This is why human genetics was chosen within this thesis as a case study for the exploration of the PBL method.

However, before improvements are made to the curriculum, certain questions need to be considered, including:

- How will genetics fit into a holistic approach which might be designed when to responding to community need?
- What kind of educational methodologies should be adopted in order to meet the needs of the Saudi community?
- Is the community-problem-based curriculum suitable for the teaching of medical students in Saudi Arabia?

2.2.5 Why was Problem-Based Learning (PBL) chosen as a potential alternative to Lecture-Based Learning (LBL)?

The focus of this investigation was to evaluate PBL as an innovative teaching method through applying it practically within Saudi medical education, rather than a more theoretical evaluation of PBL (Hmelo-Silver, 2004; Johnson & Finucane, 2000). This section aims to demonstrate why PBL has been chosen for evaluation within Saudi medical schools.

In 1993, the General Medical Council recommended that the medical curriculum be modified. Recommendations included:

1. Incorporating scientific knowledge
2. Promoting independent learning and problem-solving

3. Evaluating the student ability to learn independently
4. Reducing contact time and lecture hours
5. Appropriate methods of research on the effectiveness of PBL (Vernon and Blake, 1993).

PBL methods have since been adopted by various medical schools, because they appear to meet these requirements. In PBL, students study a constructed problem that activates prior knowledge and then requires further study in a continual process of self-directed learning and small-group discussion. Problems set are kept as close as possible to reality, thus allowing learning to occur in context and minimizing the gap between what is taught in the lecture and actual practice. This can improve motivation, encourage self-directed learning, promote the use of knowledge in a clinical context (Azer, 2003), cause less stress and increase enjoyment of learning (Kaufman et al., 1989; Albanese and Mitchell, 1993; Azer, 2003). According to Kaufman (1985), students associate PBL with new ideas, ambiguous situations and interaction with others. Norman and Schmidt (1992) believe that PBL methods help students to retain knowledge gained and thus to perform better in examinations as well as in practice.

In a comparison of LBL and PBL strategies, Coles (1985a: 308-309) state that:

> "Traditional teaching seeks to build a package of knowledge by placing blocks together and on top of each other until a predetermined structure is completed – a structure which is assumed to provide the students with an understanding of the 'whole'. In the problem-oriented approach … the composite problems are first present before broken down into their various components and dimensions, in a search for relationships and structures as part of that exploratory process. By applying this carefully as a study technique, students learn to appreciate that, while all parts are of some importance for understanding a totality, some may be more important than others and the time may come when something which may now appear as of secondary importance, later has to be restudied in depth for possible explanations and solutions not considered in the first place."

Problem-based learning (PBL) is based on both curriculum and instructional designs; whilst the curriculum design refers to *what* is offered, the instructional design refers to *how* that material is presented to the students (Barrows and Tamblyn, 1980).

Throughout this study, instructional design is considered as a sub-set of the curriculum design that is an integral part of the PBL process.

Thus PBL is a curriculum design that presents students with problems from fields of practice as stimuli for learning, with the assumption that knowledge will arise as a result of working on the problem (Barrows and Tamblyn, 1980; Boud, 1985; Azer, 2001). In PBL, self-directed learning is motivated by a need to resolve patient problems, which are encountered in both real and simulated clinical settings, providing valuable clinical experience at an early stage in the student's training (Barrows, 1994).

Mayo et al. (1993:28-30) note that

> "Problem-based learning is an educational strategy for posing significant, contextualized, real world situations, and providing resources, guidance, and instruction to learners as they develop content knowledge and problem-solving skills."

With PBL, the passive delivery of information is almost completely eliminated (Coles, 1998; Norman, et al., 2000). Instead, students are placed in small groups of five to eight people, and each group is assigned one or two faculty members whose function it is to facilitate group discussion. The students must learn not to rely upon the facilitators to teach the topic being discussed, as they may not necessarily be an authority on that particular topic (Barrows, 2000).

The object of each group meeting is not to diagnose the case, but to identify what are called "learning issues"; that is, topics for further independent and/or group study. Students then work independently on their learning issues before the next meeting, at which time the new information is discussed and refined in the context of the case (Barrows, 1994; Dolmans, 1997). If necessary, further learning issues are then identified and studied. This particular programme is designed to provide an environment in which a learning of the basic sciences will be approached with considerably more enthusiasm than under the lecture system (Colliver, 2000).

With a PBL approach to the basic sciences, it is also hoped that the students will feel more comfortable and confident in dealing with uncertainties and with the general challenge of solving clinical problems. Consequently, the students should be better prepared to enter the clinical phase of their education (Colliver, 2000; O'Neil, 2002; Dolman, et al., 2005).

The intention is that students learn both trust and responsibility as active members of the group, becoming comfortable with both receiving and giving criticism, with having their position questioned without taking it personally, and with questioning without fear of threatening others. The small-group process also provides valuable practice in sharpening students' clinical reasoning skills (Wilkerson, et al., 1991; Norman et al., 2000; O'Neil, 2002).

Educators have set out an ideal philosophy for PBL to be represented in medical education (Barrows, 1994; Vernon and Blake, 1993; Dolmans, 1997; West, 1998; Davis et al., 1992). According to this ideal, the main objective of a PBL curriculum is to foster the educational and personal development of medical students who will then:

- Take personal responsibility for learning, both during and following formal medical training.
- Command a relevant knowledge base characterized by depth, breadth and, most of all, flexibility.
- Be skilled in the critical evaluation and acquisition of new knowledge, with a commitment to life-long learning.
- Be proficient at clinical reasoning.
- Have good interpersonal skills.
- Be better prepared for entry into clinical clerkships.

The approach used in order to achieve these objectives will:

- Shift the emphasis of the programme from teaching to learning, by requiring students to be active, independent and self-directed learners; to be problem solvers rather than passive recipients of information.
- Emphasize the development of attitudes and skills which stress the acquisition of new knowledge rather than the memorization of existing

knowledge, by limiting the amount of factual information that students are expected to memorize.

- Provide a small-group environment, within which the students can work co-operatively to solve common problems in an analytical way, with faculty staff that facilitate the discussion rather than teach.

Thus it appears that PBL amply meets the learning skills recommendations set forth by the General Medical Council, at the same time providing an enjoyable and successful education. This is why this study has chosen to investigate PBL rather than any other teaching method. Indeed, numerous authors and institutions have recognized the significance of PBL and have increasingly researched, experimented with and implemented it.

A variety of literature about PBL was reviewed during the 1990s, and research was carried out in order to prove that PBL really did have advantages over LBL (Norman and Schmidt, 1992). In particular, it was discovered that PBL helped students with both self-directed and contextual learning. Firstly, the activation of prior knowledge through the study of problems aided constructive and collaborative learning, and secondly, learning in context was found to stimulate practical application of knowledge and to motivate self-directed and lifelong learning for the students.

Norman and Schmidt (1992) found that students prefer PBL because they are more able to transfer concepts to new problems. Furthermore, when PBL graduates compared themselves with colleagues taught according to conventional curricula, they noted greater improvement in their own teamwork skills, analytical skills and organisation, as well as in their ability to run meetings and to work independently (Schmidt, 1998). Teachers have also found PBL a rewarding educational method (Albanese and Mitchell, 1993).

Literature reviews conducted since the year 2000, however, have not been so positive about PBL. In a review of eight studies comparing curriculum tracks in the 1990s, Colliver (2000) concludes that there is not sufficient realistic evidence that PBL improves knowledge and clinical performances. Furthermore, in their review of 14 studies on student performance, Newman et al. (2003) find performance of students in the PBL groups to be poorer than that of students in the control groups. These findings are contrasted by those of Dochy et al. (2003), however, who analyse the effects of PBL in a review of 43 articles and confirms that PBL does in fact benefit skills, in particular the skill of applying knowledge to practice.

Farrow and Norman (2003), and also Berliner (2002), argue that randomized controlled trials, such as used for Newman's (2003) review, are not the most suitable means of assessing educational intervention. Instead of evaluating PBL simply in terms of its end goals, research should lead to a better idea of how and why PBL methods work and under what circumstances.

Overall, the reviews conducted in the 1990s, in focusing on the theoretical claims behind PBL, not only demonstrate student/faculty satisfaction with PBL, but also specify ways in which PBL meets learning skills requirements. Reviews conducted since 2000, however, are mainly concerned with a comparison of conventional and PBL curricula and with measuring the outcomes or effects of PBL. The later reviews do not focus on the notional claims behind PBL, and therefore do not provide us with better insights into why PBL may or may not work under various situations.

Although the use of PBL in Saudi medical education and in the communication of information on human genetics cannot be considered experimental in a general sense, nevertheless it represents an innovative educational methodology to Saudi medical colleges. PBL may therefore provide an appropriate focus for research into medical education. As Merriam (1990:27) notes, "innovative programmes and practices are often the focus of descriptive case studies in education." Within such studies, hypothesis-testing is accomplished by embedding an experimental design within a case study format which, in the current study, allows a comparison of the PBL and LBC formats.

2.3 Statement of the problem

The traditional LBL curriculum currently in use within Saudi medical colleges has, as mentioned earlier, attracted a lot of criticism.

Al-Sebai et al. (1982:11) propose a course of action and raised questions which lie at the heart of this thesis:

> "The concepts of innovative medical education that are recognized and described around the world should also be considered in Saudi Arabia. Saudi medical education should examine these concepts carefully to determine how they should be applied and the direction for future development. Should there be a single curricular model for the Kingdom [of Saudi Arabia] or should each school develop independently? Should Saudi schools maintain a "traditional" approach or should they follow the lead of more "innovative" schools? Is there a unique national pattern which can be developed to meet our own needs? Can we adapt and modify some of these advances in medical education?"

Because of the educational research undertaken in different publications since Al-Sebai's work was written, the present study is now able to refine these questions further.

The central problem addressed is the formidable task of creating a model for the efficient and effective delivery of PBL to future Saudi physicians. This model may be created following curriculum analysis based not only on the learning needs of medical students but also on the health needs of Saudi Arabian communities, and taking into account advances in technology and in medical theory. At present, little is known about whether the current teaching methods and learning processes in Saudi Arabia are appropriate. This study is an initial step towards providing this information for the use of Saudi medical educators.

2.4 Purpose of the research

The major purpose of this study is to evaluate the experimental introduction of PBL to undergraduate medical students (pre-clinical and clinical) in Saudi Arabia.

2.5 Research question

The study seeks broadly to answer the following question:

- What is the impact of the Problem-Based Learning (PBL) curriculum on undergraduate medical students in Saudi Arabia?

This will be achieved through a comparison of the Problem-Based Learning approach with the Lecture-Based Case (LBC) approach, which adds a case study to the traditional lecture-based (LBL) approach. PBL will therefore be compared to LBC rather than to LBL, because of the inclusion of case studies.

The educational objectives of PBL are to:

1. Structure knowledge for use in clinical context
2. Develop an effective clinical reasoning process
3. Develop effective self-directed learning skills
4. Increase motivation for learning.

The lecture-based case (LBC) format is the lowest stratum of Barrows's taxonomic model of PBL (1986; described in Chapter 3.4), and provides very little opportunity for the adoption of these educational objectives. The self-directed learning aspect is not introduced, and exposure to activities that would encourage clinically contextual knowledge structuring, effectiveness in clinical reasoning and motivation to learn are minimal.

This study will show that in order to achieve curriculum objectives, a change in teaching methods is required.

2.6 Objectives of the study

While seeking answers to the research question, the study aims to achieve the following objectives:

1. To compare PBL undergraduates to LBC (lecture-based case) students in Saudi Arabia, with particular regard to (a) ability to fulfil the knowledge

requirement and (b) changes in student attitude towards the health care needs of the population.

2. To examine the efficacy of PBL by assessing (a) how the student's learning methods are altered to increase problem-solving and critical-thinking skills; (b) whether retention of factual knowledge is improved; (c) whether self-directed learning skills are increased; and (d) whether motivation and interest in learning are enhanced.
3. To compare clinical students' opinions towards PBL with those of pre-clinical students learning in a LBC format.
4. To assess the relationship of academic performance and preparation, cognitive learning style and demographic factors with differences in achievement between the PBL and the LBC approaches.
5. To determine the influence on students' level of preparation (i.e. clinical or pre-clinical) as a result of the PBL format.
6. To identify the advantages and disadvantages of using a PBL format for Saudi undergraduate medical students.

2.7. Research hypotheses

From the above objectives, fourteen hypotheses were formed, based upon previous PBL research in medical education curricula in other countries (reviewed in the following chapter). This thesis will evaluate these through a study of pre-clinical and clinical Saudi undergraduate medical students.

It is hypothesized that students taught in PBL:

1. Have higher scores in examinations than students taught in a lecture-based format.
2. Have a better awareness of their genetics knowledge requirement than those taught in a lecture-based format.
3. Have better problem-solving and critical-thinking skills than students taught in a lecture-based format.
4. Have a higher capacity of knowledge retention than those taught in a lecture-based format.

5. Have better motivation than students taught in a lecture-based format.
6. Have more confidence in conducting self-directed learning than students taught in a lecture-based format.
7. Are generally more prepared for each session than those taught in a lecture-based format.
8. Are less likely to be confused, frustrated or stressed when learning about medicine than students taught in a lecture-based format.
9. Are less likely to be confused, frustrated or stressed when working with patients than students taught in a lecture-based format.
10. Are less likely to be confused, frustrated or stressed regarding a career focusing on medicine than students taught in a lecture-based format.
11. Are less likely to be confused, frustrated or stressed regarding problems associated with medicine than students taught in a lecture-based format.
12. Have a better learning experience than students taught in a lecture-based format.
13. Are more competent in the use of resources available than students taught in a lecture-based format.
14. It is further hypothesized that PBL tutors have a higher opinion of PBL learning methods than LBC tutors of LBC methods.

2.8 Assumptions of the study

The conduct of this study is based on assumptions which, if false, could alter the internal and external validity of the experimental finding of this study. These require a brief description.

It is assumed that the colleges of medicine are collectively representative of medical education in Saudi Arabia, but is taken into account that the colleges' students and staff are significantly different from each other even when following a similar traditional medical education curriculum. It is further assumed that the sample of students used in this study is representative of Saudi students, that they respond truthfully and without bias to the study questionnaires and that the conditions under which each student does so are the same. Equal assumptions are made regarding faculty members participating in the study.

It is also assumed that the genetics modules are representative of medical education more generally, and that the findings of this experiment will apply if tried out on a country-wide scale.

Finally, it is assumed that the information obtained from participants captures the relevant dimensions of PBL, as well as characteristics which allow a comparison of PBL and the LBC format.

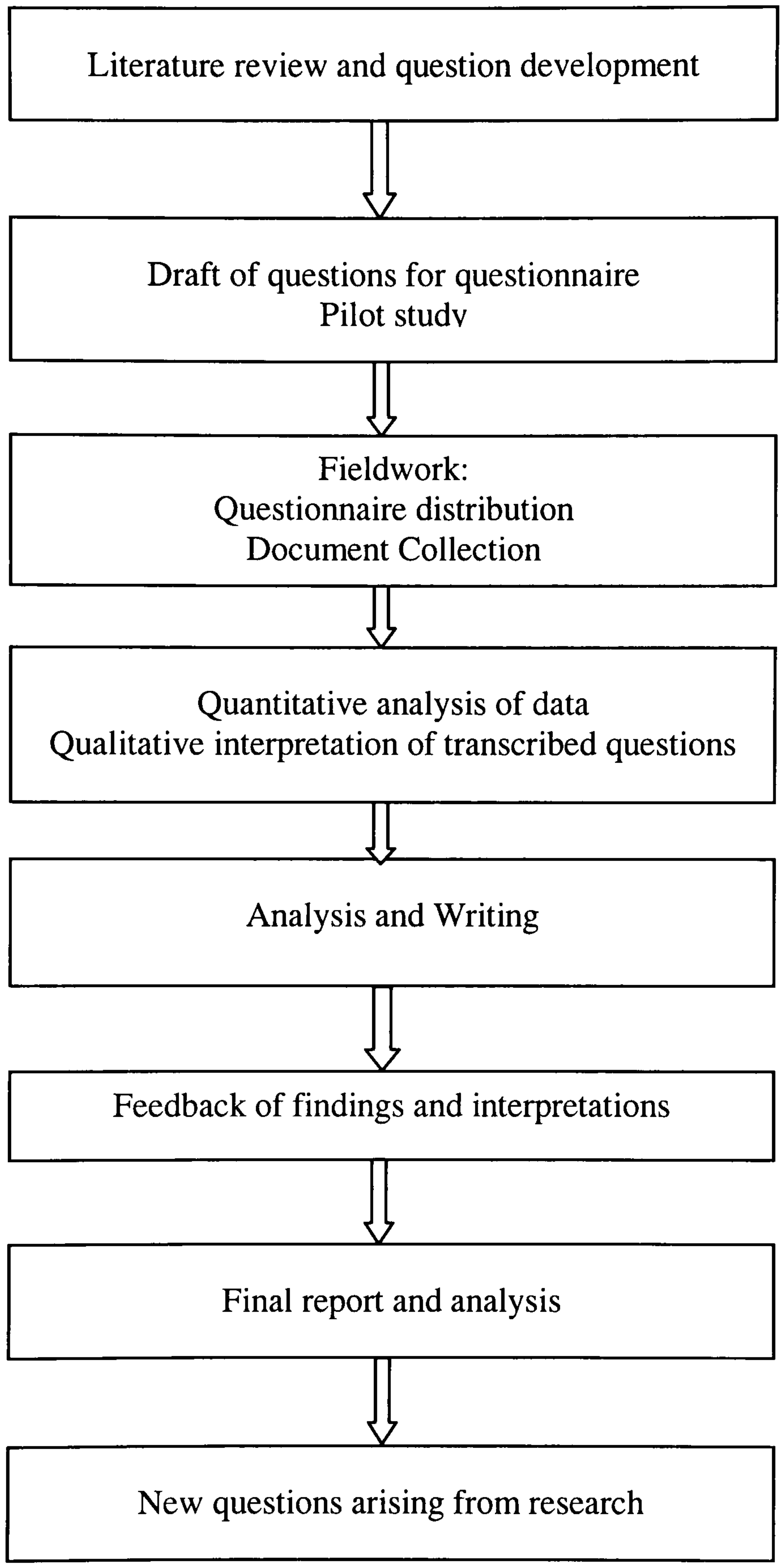
2.9 Structure of the research

This study was carried out using a variety of research methods. It is often said that in the social sciences there are two different types of research: quantitative research and qualitative research (Kvale, 1996). Following the advice of Merriam (1990: 59), this study takes the view that different research methods and approaches can be mutually supportive.

Quantitative data collected through questionnaires about cognitive behaviour, attitudes and skills was supplemented by qualitative data gained from open-ended questions. This made possible a much more in-depth and thorough data analysis than would have been possible on the basis of statistical analysis alone (see figure 2.1).

It should be noted that this study has its starting point in the experience of the researcher. I work at King Faisal University as a lecturer and director of medical education, and am responsible for curriculum evaluation. As a member of staff in a Saudi Arabian university, I have first-hand experience of many of the problems they face, and my understanding has obviously shaped the interpretations of the data that are presented in this study. No attempt was made to make this a participant observation study, but my participation in Saudi academic life has clearly helped in my understanding of the research data, in part because it gave me access to people who could understand the purpose of the research, with whom I will then share interpretations and ideas.

Figure 2.1 Research process



This is a schematic representation of how the work was done. At each stage, new questions emerged and the data was reviewed again to see if it helped to provide answers. This process is continuous and demands in-depth interpretation at each stage.

This thesis is presented in six sections and has eleven chapters:

Section I Context and Aims

Chapter One: Introduces Saudi Arabia as the main location of this study, describing the country's education system in general and explaining in detail its system of medical education and the current curriculum used within Saudi colleges of medicine. It also sets out a summary of past revisions of the medical curriculum in Saudi Arabia.

Chapter Two: Describes the reasons for this study. It details the aims and purposes of the study, including the research question and the research hypotheses.

Section II Review of Related Literature

Chapter Three: Focuses on the literature which examines problem-based learning (PBL) in medical education.

Section III The Empirical Study

Chapter Four: Describes and evaluates the research methodology and research design of the current study.

Section IV Results and Data Analysis

Chapter Five: Deals with the quantitative and qualitative results and data analysis for pre-clinical students.

Chapter Six: Deals with the quantitative and qualitative results and data analysis for clinical students.

Chapter Seven: Summarizes the major findings from pre-clinical and clinical students.

Section V Discussions

Chapter Eight: Discusses findings in relation to the results of the study and Margetson's understanding of problem-based learning in action.

Chapter Nine: Presents the arguments of other education writers supporting the belief that the issue is not one of separation of understanding from action, but of what kind of action is involved in professional practice and what kind of knowledge is required to drive it.

Section VI Recommendations and Suggestions for Further research

Chapter Ten: Presents a 'practice and experimental-based learning model' (PEBL). This model is set out, described and explained in response to the needs highlighted by the study results.

Chapter Eleven: Sets out the limitations of the study and gives indications for further research.

2.10 Summary

This chapter has highlighted problems within the traditional medical curriculum in Saudi Arabia and has suggested alternative teaching methods. It is hoped that by using the human genetics unit as a framework, these innovative teaching methods may be assessed and compared with more traditional ones. The outcome of this experiment may be vital in understanding which methods of teaching medical education are most effective in preparing future Saudi physicians aware of and able to fulfil the ever-changing needs of Saudi communities.

It is noted that the outcome of experimentally applying a PBL style of teaching will be slightly different to the outcome of its long-term use, but the experiment will act as a starting point which will hopefully encourage a modification of the curriculum.

Having outlined the aims of the study, these will now be investigated and explored further in the chapters that follow.

Section II: Review of Related Literature

Chapter Three

Review of Related Literature: Problem-Based Learning

Chapter Three

Problem-Based Learning

3.1 Introduction

Medical educators worldwide agree that there is need for improvement within the education process. Many researchers feel that problems presented by the more commonly-used lecture-based approach (LBL), including curriculum overload, duplication of material and reduced student motivation (Simpson, 1972; Madison, 1978; Coles and Fish, 2005) could be resolved through the use of problem-based learning (PBL) methods. As a result, the number of medical colleges implementing PBL has been increasing worldwide over recent years (Albanese, 2000).

Some of the colleges using PBL will be used as case studies within this chapter, which aims to review the techniques of PBL and to comment on its advantages and disadvantages.

3.2 The history and origins of problem-based learning

In 1918, the Carnegie Foundation employed Abraham Flexner to assess the quality of existing medical schools in the U.S. and to make recommendations for their improvement. At that time, medical education within the U.S. was in a state of chaos, with more than 150 schools – most of which were not affiliated with institutions of higher education – providing curricula of varied length and quality. Flexner recommended that many of the weaker schools be closed and the remaining stronger schools merged, and also declared that all schools should be affiliated with universities of higher education. Moreover, he recommended that the medical curriculum be interactive, and not one in which the students were expected merely to regurgitate facts gained through lectures, in line with initial intentions within U.S. medical education of teaching small groups on a problem-solving basis in the form of apprenticeships. At their inception, Flexner said, medical schools were developed to supplement, not supplant, the apprenticeship system (Flexner, 1910); yet most of the medical schools had adopted the LBL format, in which context medical students became passive learners (Coles, 1985b; De Volder and de Grave, 1989).

This pattern in medical education was not significantly altered until 1969, when the McMaster University medical school programme was developed in Canada in order to prepare broad-spectrum or "undifferentiated" physicians using the then controversial problem-based learning method (Hamilton, 2005). Barrows (1994: 7) later notes:

> "Although problem-based learning has now become an increasingly popular education method in medical education, the original problem-based, self-directed learning curriculum at McMaster University, featuring small learning groups with a faculty tutor, was established more than 20 years ago. As a newly created school, McMaster began with this revolutionary problem-based curriculum after a reasonably luxurious 4-year opportunity to set it up. A few years later, two more new schools widely spaced across the globe, Maastricht (University of Limburg) in the Netherlands and the University of Newcastle in Australia, also initiated a problem-based learning curricula. There was much cross-fertilization between all three schools."

Many universities have since begun to adopt the system of problem-based learning, resulting in large changes and advancements in the implementation and teaching of the curricula. As Bligh (2000:620) states,

> "We have taken into account the growing impact of information technology, and the emergence of problem-based learning as a teaching method of choice by many medical schools."

In 1973, the Project for Learning Resources Design (PLRD) was established at McMaster to further the development of 'problem simulation formats' for problem-based learning skills, which would encourage the development of clinical reasoning in students. These formats were based on the "problem boxes" first designed for medical students on a neurological clerkship at the University of Southern California in 1969, and were later developed further at Southern Illinois University Medical School.

In the 5-year period between 1976 and 1980, significant research was conducted on the application and evaluation of the problem formats, tutor techniques and curriculum design that which had been implemented in the McMaster neuroscience programme (Barrows and Tamblyn, 1980). This research found that the general educational goals for students in the programme at McMaster were:

1. To identify and define health problems and to search for information in order to resolve or manage these problems.
2. To examine the underlying physical or behavioural symptoms of a health problem. A spectrum of phenomena might be included, from physiology and biochemistry to environment and family relationships.
3. To recognize, maintain and develop the personal characteristics and attitudes required for professional life.
4. To develop the clinical skills and to learn the methods required to define and manage patients' health problems, including their physical, emotional and social aspects.
5. To become a self-directed learner, recognizing personal educational needs, selecting appropriate learning resources and evaluating progress.
6. To be able to critically assess professional activity related to patient care, health care delivery and medical research.
7. To be able to function as a productive member of a small group that is engaged in learning, research or health care.
8. To be aware of and able to work in a variety of health care settings (Neufeld and Barrows 1974: 1040).

These goals here described by Neufeld and Barrows later became PBL goals; an overview of the many authors who have described the goals and objectives of PBL is shown in table 3.1.

Table 3.1 Goals and objectives: references cited

Goal or Objective	Reference
Acquiring a retrievable usable knowledge base	Barrows, 1985; Armstrong, 1991; Towle, 1991; Azer, 2001.
Acquiring professional clinical reasoning skills	Barrows, 1985; Armstrong, 1991; Engel, 1991; Towle, 1991; Azer, 2001.
Acquiring self-directed learning skills	Echt & Chan, 1977; Barrows and Tamblyn, 1980; Barrows, 1985; Towle, 1991; Azer, 2001; Newman,2005
Encouraging independent critical thinking skills	Barrows, 1985; Coles, 1991b; Towle, 1991; Azer, 2001
Meeting individual student needs, styles and backgrounds	Barrows, 1994; Coles, 1991b; Khoo, 2003
Developing a concern for community problems	Des Marchais et al., 1992; Khoo, 2003
Developing creating thinking	Towle, 1991; Maudsley et al., 2000 Schmidt, 1998; Fish and Coles et al., 2005
Approaching a medical problem scientifically	Barrow and Tamblyn, 1980; Dolmans, 1997; Dornan., 2006
Acting as leader, collaborator, coordinator and informant in a team	Barrows and Tamblyn, 1980; Maudsley, 2003; Newman,2005
Fostering active learning	Dornan, 2006; Coles, 1998; Azer, 2001

At the heart of the PBL movement are two very important factors in human behaviour: attitude and knowledge. Firstly, the prevalent attitude driving the implementation of PBL methods is one of dissatisfaction with the LBL and discussion model (Neufeld and Barrows, 1974; Schwartz et al., 1991). This general dissatisfaction stems from the realisation that we learn naturally in everyday life, but that classroom activity becomes tedious and hard work in an unnatural way, unlike the learning we experience in our daily world (Dornan, 2006). As a result, Barrows (1985) found a "paucity of basic knowledge" in the students he taught (1985: 9). This led to research on learning theories, which found that the current lecture-based model takes advantage of how people learn (Gagne et al., 1988). Resulting knowledge about how people learn is the second major driver for the implementation of PBL.

As a direct result of research, experiments and the success of other schools using PBL, some of the most prestigious institutions began introducing PBL to their curricula. In 1985, Harvard Medical School began a trial PBL track called the "New Pathway," which was quickly expanded to its entire class in 1987 (Tosteson et al., 1994). In Canada, a country considered at the forefront of medical education reform in the post-World War II years, most of the sixteen faculties of medicine have been engaged in a curriculum reform introducing PBL methods (Neufeld et al,, 1989).

While most of the emphasis is on the use of PBL in medical education, educators in other disciplines across the world have begun experimenting with PBL as well (Hamilton, 2005). In 2000, Savin-Barden reviewed fifty institutions worldwide, nearly half of which were non-medical, that were already using PBL. The first institutions to implement PBL are outlined in table 3.2.

Table 3.2 Institutions that first implemented PBL

Institution	Country	Subject	Year of Implementation
University of Technology	Australia	Law	1987
University of Manchester	United Kingdom	English	1988
National University of Singapore	Singapore	Informatics	1988
University of London	United Kingdom	Industrial Engineering	1988
Manchester Metropolitan University	United Kingdom	Management and Economics	1988
University of Aberdeen	United Kingdom	English	1989
Netherlands International Institute of Management	Netherlands	Management and Economics	1989
Edge Hill College	United Kingdom	Informatics	1990
Imperial College of Science and Technology	United Kingdom	Mechanical Engineering	1991
Queensland University of Technology	Australia	Optometry	1991
University of Bristol	United Kingdom	Social Work	1992
University of Kentucky	United States of America	Social Work	1993
University of Warwick	United Kingdom	Law	1993
Robert Gordon's Institute of Technology	Scotland	Industrial Engineering	1994
University of East London	United Kingdom	Architecture	1995
University of Newcastle	United Kingdom	Architecture	1996
Coventry University	United Kingdom	Industrial Engineering	1998
Imperial College	United Kingdom	Industrial Engineering	1998

3.3 Characteristics of problem-based learning

The term "problem solving" is described by Walton and Matthews (1989: 542) "as a search through a vast maze of possibilities, searching the maze selectively and reducing it to manageable proportions." The term has, in fact, a vague meaning, the range of meanings assigned to it including ideas within medicine which differ somewhat from ideas within other fields (Ausubel, 1968). In fact, for the most part, in medical education, "problem solving" has been generally used to refer to those skills necessary to arrive at a diagnosis (McGuire, 1985). The terms "problem solving" and "diagnosis" have thus been suggested as synonymous, along with other terms that are often used interchangeably with problem solving in medicine, such as "clinical reasoning process," "medical decision-making," "clinical judgment," "re-diagnostic reasoning," "information processing," "medical inquiry" and "decision analysis" (Barrows, 1994). Much of the literature regarding problem solving in medicine states that diagnoses are formulated through the hypothetico-deductive method of reasoning (Barrows, 1994), i.e. the procedure of forming multiple hypotheses to explain the advance of the problem, before testing those hypotheses and modifying and/or rejecting them as appropriate (Barrows, 1985). This approach to problem solving has been widely accepted as the manner in which a medical decision is reached (Berner, 1984).

As Berkson states (1993), PBL is a learning system based on a hypothetico-deductive model, with a specific emphasis on the individual medical student's capabilities and characteristics rather than on the amount of information memorized or mastered. The problem to be solved serves as the focus for the development of clinical reasoning and self-directed learning skills, and is the stimulus for acquiring the knowledge needed to understand underlying mechanisms (Barrows and Tamblyn, 1980). Coles (1990b: 76-78) calls this process "elaborated learning":

> "Elaborated learning can only be promoted educationally when three crucially important curriculum features are present – concerning the context of learning, the kind of information presented and the nature of the learning activity."

A problem may be presented in a variety of ways within a PBL methodology: as a hypothetical patient community problem (CP) a computerized patient simulation (CPS), a sequential patient simulation (SPS), a live standardized patient (SP), or an actual live patient. These varied formats permit free inquiry by students as they gather pertinent historical data, conduct physical or other examinations, and carry out laboratory or related procedures. Unlike LBL curricula, PBL is focused on the multiple aspects of these specific cases rather than upon whole subject areas. Thus instead of being presented with facts organised into a hierarchy of concepts, students work in small groups to tackle specific problems, giving them greater control over the direction of their learning experiences.

3.4 Taxonomy of problem-based learning

According to Barrows (1986) and Savin-Barden (2000), the classic PBL model is designed for small groups of five to eight students with one or two tutors, or facilitators, per group. The model has six steps or facets:

1. The problem is introduced first of all, before any preparation or study has occurred.
2. The problem is presented to the student in the same way as it would be presented in reality.
3. The student works with the problem, applying and evaluating knowledge in a way appropriate to his/her level of learning.
4. Areas of learning are identified while working with the problem and are used as a guide to individualized study.
5. The skills and knowledge acquired by this study are applied to the problem to evaluate the effectiveness of learning and to reinforce learning.
6. The learning that has occurred in working with the problem and in individualized study is summarised and integrated into the students' existing knowledge and skills.

This is a holistic and interdisciplinary model, considering both the patient and community needs, and not just a single disease state or body system. It is also student-centred and encourages self-directed learning in that it requires students to identify their learning needs, develop plans to satisfy them, and assess their own progress.

Barrows (1986) wrote a taxonomy of PBL, which rates the effectiveness of the most common types of PBL methods on a scale of 1 to 5, where 5 is the most effective. This is represented below in table 3.3.

Table 3.3 Barrows's taxonomy of PBL methods (1986: 483)

	SCC[a]	CRP[b]	SLD[c]	MOT[d]
Lecture-based cases (LBC)	1	0	0	1
Case-based lectures (CBL)	2	2	0	2
Case method (CM)	3	3	3	4
Modified case-based (MCB)	4	3	3	5
Problem-based (PBL)	4	4	4	5
Closed-loop problem-based (CPBL)	5	5	5	5

Acronyms: a. Structuring of knowledge (SCC) c. Effective self-directed learning skills (SLD)
b. Clinical reasoning process (CRP) d. Increased motivation for learning (MOT)

The PBL methods in table 3.3 can be seen to be on a continuum ranging from near total teacher control to near total student control of learning. In the LBC format, the most teacher-centred of the PBL methods, the teacher presents new information in the form of a lecture, followed by a case study designed to demonstrate the relevance of the lecture material. For the case-based lecture method (CBL), however, this order is reversed. Here, case studies are presented first, and serve as a focus point for the lecture that follows. In the case method (CM), the students themselves research a case study and prepare for a teacher-centred discussion in a later class, whilst the modified case-based format (MCB) involves students in a small, student-centred tutorial that is driven by a pre-set problem. The closed-loop or reiterative PBL method (CPBL) is considered the most student-centred, extending the PBL strategy to incorporate student assessment of reasoning strategies and source credibility, which is then applied back to the problem. Barrows (1980) considers this the best method to address specific educational objectives; it is also, however, the most complex, the most time-intensive, and the most expensive method.

Besides Barrows's taxonomy, it is interesting to note that of Savin-Barden (2000), which avoids the use of acronyms and states instead that PBL is defined simply by the existence of the following features: self-directed learning, small-group process and problem case study. For Savin-Barden, there is no need to distinguish PBL from CPBL; so long as a curriculum has the principles of PBL, it is PBL. According to Savin-Barden's taxonomy, the LBC and CBL methods are not considered PBL.

Although each taxonomic level involves problem study, the processes may be quite different, and it is important to distinguish between PBL formats before literature reports on the use of PBL can be considered across settings (Blumberg et al., 1990). Margetson (1999) distinguishes between two forms of PBL: transitional semi-PBL and rigorous PBL, and offers in addition a further description of 'Two Conceptions', outlined below.

3.4.1 Conception I: The "Convenient Peg" of problem-based learning

Margetson (1999) describes this conception (C.I) as a two-stage process of learning. First, a pre-clinical, theoretical foundation of knowledge is acquired in what has often been referred to as the "basic" sciences, i.e. anatomy, physiology and biochemistry. Secondly, and much later, students learn how to reason clinically towards diagnosis and treatment; and only at this stage do they learn how to solve systematically or manage clinical problems by applying their basic science knowledge.

Thus a clinical problem and its solution are separated within education. Incidental discussion of a clinical solution may occur, but at this stage falls outside curriculum objectives and may be strongly discouraged by tutors. Although hypothetico-deductive reasoning is important at both stages, it is used for different purposes, namely acquiring 'basic' knowledge in the first stage, and learning to reason clinically and make clinical decisions in the second. This two-stage process provides a convenient "peg" on which to hang knowledge acquisition of the basic sciences and offers the convenience of using clinical problems as a motivating factor. Schmidt (1993) and Norman and Schmidt (2000) confirm this, suggesting that linking defined medical problems to knowledge acquisition in the basic sciences leads to a more effective recall of information when students enter clinical situations.

3.4.2 Conception II: The "Growing Web" of problem-based learning

Conception C.II allows for a greater awareness that problems are not always what they appear. In fact, problems indicate problematic solutions. Understanding and dealing with them can often be difficult and elusive. It is important to remember that medical problems do not necessarily present themselves as 'packaged' to match academic divisions between "basic" sciences and "clinical practice"; rather, information, concepts, reasoning, skills and attitudes are acquired in relation to each other, complementing each other holistically in the growth of the student's understanding.

C.II views the role of a problem as providing the focus within the rich context in which medical cases arise, and considers it important that problems in the educational context simulate as closely as possible the kinds of situations medical practitioners encounter in their everyday lives. Margetson further states that learning to become a competent clinical practitioner is best seen as a coherent whole from the beginning.

3.5 Implementation of problem-based learning

The implementation of PBL varies from school to school, where interpretation and use of learning issues evolve in conjunction with course content, learning activities, curriculum development, evaluation and review (Blumberg, 1988). PBL may be adopted across a school, as a curriculum operating concurrently with LBL, or as an instructional technique used within individual courses in the curriculum (Vernon and Blake, 1993; Creedy et al., 1994; Dorcas et al., 1999; Salvatori, 2000; Amin and Khoo, 2003). In some medical schools, the entire curriculum has been reorganised in order to adopt a problem-based approach.

Where PBL is run concurrently with LBL, this is called a parallel curriculum. This approach has been adopted by several universities, including Bowman Gray School of Medicine at Wake Forest University, Harvard University, the University of New Mexico, Southern Illinois University School of Medicine, and Michigan State University College of Human Medicine. The PBL curriculum at the University of

New Mexico is unique in that periods of small group-tutorials are alternated with rural clerkships (Kaufman and Mann, 1996; Azer, 2001; Hamilton, 2005).

The parallel curriculum at Bowman Gray was initiated in the academic year 1987-1988, admitting 18 students to the PBL curriculum and 90 students to the LBL course each year, both 4-year programmes leading to an M.D. degree. During the first year of the PBL curriculum, tutorial groups progress through a sequence of 40 patient problems in areas of basic, clinical, and behavioural sciences. The cases are followed by a series of 30 encounters with hospital and clinic patients, in order to develop further clinical context for learning the basic sciences, particularly in the areas of biochemistry, anatomy and pharmacology. This approach provides a compromise between student-centred and faculty-centred learning.

Some institutions – such as McMaster University, the University of New Mexico and Southern Illinois University School of Medicine – maintained a student-centred "classical" interpretation of PBL, while the curricula in PBL programmes at Michigan State University College of Human Medicine (Track II) and Mercer University School of Medicine were faculty-centred. In the latter case, the faculty generated learning issues and identified specific reading assignments for students.

The new curricula at Bowman Gray (Parallel Curriculum), Harvard University Medical School (New Pathway), and Rush Medical College (Alternative Curriculum), on the other hand, enabled students to generate learning issues themselves, but also made faculty-generated learning issues available for comparison, either at the end of a case or at a point at which students were most of the way through a case. Here, as with the student-centred curricula at McMaster, New Mexico and Southern Illinois University, there was provision for negotiation regarding the development and relative emphasis of student-generated learning issues (Blumberg, 1988).

The medical curricula at McMaster University, at the University of Newcastle (New South Wales), and at Rijksuniversiteit Limburg (Maastricht) use clinical problems as the basis for learning within small groups, with no lectures or conventional class-laboratory exercises and no separation between pre-clinical and clinical experiences. In these universities, the PBL curriculum is structured into curriculum blocks, each of which presents cases relating to a common theme or an organ system. Objectives define the competencies required, and clinical problems identify the knowledge, understanding and skills which students are expected to acquire during the course of study (Neame, 1984; Schmidt et al., 1987; Donner and Bickley, 1990; Harden et al., 2000; Maudsley, 2003).

In 1973, the College of Human Medicine at Michigan State University developed a problem-oriented curriculum called the "Track II Programme", providing an alternative to their LBC Track I Programme (Davis, 1994). According to Davis (1994), Michigan's programme is the most structured of the PBL medical school curricula, with cases focused on clinical problems such as anaemia, jaundice, back pain, fever and dyspnoea, with the aim of identifying specific questions to be addressed, and pointing students towards appropriate reference materials and related readings.

Furthermore, at the University of Otago Medical School in Dunedin, New Zealand, lecture-based curriculum activities are preceded by a "Case-based Learning Day", a brief, self-contained activity designed to introduce students to self-directed learning and basic science material through clinical cases, tutorial discussion groups and the use of printed and audio-visual resources (Schwartz et al., 1978).

There are a variety of issues involved in the implementation of PBL, as shall be discussed in the following section.

3.6 Issues involved in changing to a PBL curriculum

Previous literature on PBL has outlined the issues involved in implementing its techniques. These issues may be categorized under 7 headings, which this review will now analyse in terms of their relationship to each other within the PBL curriculum. The 7 headings under which these issues are summarised are:

- 3.6.1 Curriculum Structure
- 3.6.2 Assessment
- 3.6.3 Group Process

3.6.4 Facilitators

3.6.5 Problem Development

3.6.6 Resources

3.6.7 Cost

3.6.1 Curriculum Structure

The PBL curriculum structure is modelled after the foundational work of the "McMaster Philosophy" and Barrows and Tamblyn's (1980) seminal works on PBL curriculum design. Overall, curriculum structure in PBL is designed to present students with problems they have not previously studied, which are presented through high-fidelity (realistic) scenarios, allowing students to identify their own knowledge deficiencies.

Each of the PBL models reviewed by previous literature follows the generic Barrows and Tamblyn model mentioned in section 3.4. While every design has its own unique features, the similarities between the models provide a common ground for determining which aspects are critical for a given PBL curriculum. They each centre on cases or problems and usually include learning objectives, issues for discussion, suggested teaching strategies, related resources, study materials, bibliography, timetable and rules. These materials may be arranged in handbook form (Colby, Almy, and Zubkoff, 1986), problem boxes (Barrows, 1994), course books (Pales and Gual, 1992), videos (Smith, 1985), situation improvement packages (Amin and Khoo, 2003), discipline maps (Engel, 1991), Web/CD-ROM program (Kamin, 1995) or case design packages (Gilkison, 2003). All are designed for the same purpose: to provide a learning environment where students have responsibility for their own learning.

A key strategy of PBL curricula is the reiteration of subject matter using increasingly difficult problems. Increasing the problem difficulty creates a matrix where the vertical development of specialized subject areas is woven through the horizontal progression of problems. This puts emphasis on the general pattern of problem-solving and on the interdependence of social, technical, cultural and managerial factors within it (Amin and Khoo, 2003).

Amin and Khoo discuss the development of a PBL curriculum in a way that resembles a traditional instructional system design. Their prescription for developing a curriculum is to evaluate the environment, define the problem, explore options, develop a plan, implement a plan and evaluate the outcomes.

Another strategy, applied by Coles (1985a), introduces workshops to help students deal with the radically different nature of learning in a PBL environment. The workshops are used to increase students' confidence and skills in group processes, problem solving and self-assessment, and to train students in stress management and ways of coping with the change they will experience when such a different approach is taken. The addition of these workshops to the curriculum structure is aimed at smoothing the transition from LBL to PBL.

In another approach, Post and Drop (1990) introduce creative thinking to the PBL curriculum, using mind maps as a way of helping students develop the skills of divergent and creative thinking. These thinking skills foster students' ability to generate ideas and consider possibilities, and ease cognitive dissonance when listing options and pursuing the maybes.

The various ways of presenting PBL within a curriculum have, of course, a direct effect on modes of assessment, as we shall now see.

3.6.2 Assessment

When reviewing curricula and/or moving to a PBL approach, assessment methodologies may need to be re-evaluated, since LBL assessment is largely incompatible with the goals and objectives of PBL. Whilst Vlutin (1999) argues that the ultimate aims of LBL and PBL must be the same and that, therefore, their modes of assessment must be the same, Dolmans et al. (2001:135) point out that conventional assessment approaches are not "goal free, illuminating, ethno-methodological, qualitative, and responsive." In a PBL curriculum, however, students gain the ability to manage their own learning, to assess themselves and to relate to patients, peers and other professionals. For Norman (1992:59), this must affect methods of assessment:

> "If we wish our students to learn the skills and knowledge associated with community orientation, health promotion, population and public health, critical appraisal, lifelong learning, interdisciplinary learning or self-appraisal, then we are obliged to assess these objectives in a meaningful, reliable and valid fashion."

Assessment comes into play in at least four different ways: (a) context evaluation, requiring an examination of the setting of the professional programme; (b) input evaluation, demanding close examination of programme plans and objectives; (c) process evaluation, looking at ways plans become reality; and (d) product evaluation, requiring a detailed examination of the outcomes (Dolmans et al., 2001). The current review focuses on product evaluation, since this falls in line with the research focus, and because the bulk of literature on assessment refers specifically to product evaluation.

Because of the shift away from purely theoretical knowledge and understanding and toward problem-solving skills and self-directed learning, most PBL courses use a pass/fail grading system. Barrows and Tamblyn (1980) identify three critical targets for PBL evaluation: (a) clinical reasoning skills; (b) clinical technical skills; and (c) self-study skills, and assert that educational assessment tools should be designed to help students develop their own approaches to self-evaluation, which can be continued throughout their lives. PBL evaluation should be a constructive and helpful process, leading to improved learning and performance, and to increased openness for helping themselves and others. The assessment tools proposed by Barrows and Tamblyn are shown in table 3.4 below.

Table 3.4 PBL assessment tools

Client reports	Constant feedback
Consultant reports	Debates
Discussion	Essay exam
Face-to-face interviews	Final exams
Log	Multiple choice
Observation	Oral exam
Oral presentation	Peer-assessment
Peer jury assessment	Problem write-up
Records of books, articles, and software	Self-assessment
Simulations (written and/or live)	Think-out-loud exams
Tutor-assessment	Tutor jury assessment
Work completion or short answer	Self-assessment of problem-solving skills, motivation, effort and attitudes

Many of these assessment tools are, however, unfamiliar, hard to quantify objectively, and more labour-intensive than traditional tools (O'Neill et al., 2000; Mclean et al., 2003; Chamberlain, 2005). Similarly, PBL evaluation includes many abstract concepts not easily measurable. In PBL, no matter which tools are used, the final assessment is ultimately up to the facilitators' understanding and synthesis of an individual student's understanding and performance (Chamberlain, 2005). Barrows and Tamblyn (1980) recommend that the assessment tools be used according to learning objectives and tool properties, and offer suggestions for evaluating the effectiveness of assessment tools (table 3.5).

Table 3.5 PBL evaluation tools and techniques (Barrows, 1980: 115)

Characteristics of Evaluation Techniques and Tools • Process versus Content • Process versus Outcome • Reliability (two examiners, one score – reliability) • Validity (content adequately samples area measured) • Fidelity (extent to which test resembles real life) • Feasibility (ease of administering, scoring and analysing) How to Evaluate Tools • Multiple Choice/True-False Questions (information recall only) • Work-completion or Short-Answer Questions Poor reliability with questionable validity • Oral Examination • Essay Examination Valid with questionable reliability • Observation of a Patient Interview and Examination • Review of Case Record, and Record Audit

In summary, it is clear that assessment has an important role in helping students develop their learning skills. However, traditional assessment for measuring stored knowledge against pre-set objectives does not promote the PBL objective of creating a life-long learner who performs ongoing self-appraisals. Furthermore, whilst there are many alternative assessment tools available for PBL, each requires an understanding of the tool and of the knowledge and/or skill it measures.

3.6.3 The group process

The PBL method is based on small groups of students learning together and from each other. This group process, and its apparent advantages and disadvantages, have been extensively reviewed within the literature on PBL – since groups are the social sphere in which many of the PBL goals and objectives are played out, focusing on the group process is a way of examining the PBL curriculum as a whole.

Neufeld and Barrows (1974) describe the small-group tutorial as a learning laboratory of human interaction, and identify the following benefits of using small-group tutorials:

1. Developing interpersonal skills.
2. Becoming aware of emotional reactions of self and others.
3. Learning how to listen.
4. Learning how to give and receive criticism.
5. Learning about educational planning.
6. Providing a forum for group problem-solving through the pooled resources of the group members, which include academic training, experience, personality and perspective.
7. Providing an opportunity for self-evaluation by which a student can compare his own learning progress informally with that of his peers.
8. Developing a sense of responsibility for the learning progress of each member.
9. Learning how to give honest and accurate feedback to each other.

Other authors have reiterated this, and have added further benefits, goals and aims to the list:

1. Allowing students to initiate and sustain discussion (Wilkerson, Hafler & Liu, 1991).
2. Fostering the development of problem-solving skills (Echt & Chan, 1977).
3. Training students in small-group leadership (Smith, 1985).
4. Motivating learning, heightening inquisitiveness, encouraging holistic learning, building self-confidence and improving communication and understanding of people (Amin and Khoo. 2003).
5. Fostering elaboration of knowledge in a safe environment (Coles, 1998).
6. Allowing individual attention as well as helping build friendships in a context of accountability where knowledge and experience are used as pooled resources (Barrows, 2000).
7. Building teamwork skills and developing trust between individuals (Fish and Coles, 2005).
8. Providing an open, free, stimulating, cooperative and realistic environment that is responsive to change (Moore, 1991).

Azer (2001) claims that the success of the PBL curriculum depends on good group dynamics, and that developing functional group interaction is critical to the success of the process. Yet research into PBL offers scant information on the nature of group process training. Barrows (1994) shows that at the beginning of a PBL course, group activities consist of introductions: establishing an open constructive working climate and defining responsibilities and group objectives. Whilst Barrows affirms that "most of these activities will not need to be repeated before each new problem" (1994: 55), it is clear that there is still a paucity of information about how even these introductory activities are to be carried out.

Another concern is regarding how and when individuals are weaned away from the group in order to prepare for autonomous learning. Indeed, there is evidence that some students do become overly dependent on the small-group environment (Albanese and Mitchell, 1993; Khoo et al., 2001; Azer, 2001). Barrows (1985:8) suggests that

> "At some point in the curriculum the group process should be abandoned in PBL and the students encouraged to continue in the PBL process by individually anticipating their approach to clinical work."

Other drawbacks of the group process include a variation in the level of individual commitment, meaning that some students work harder than others; personality differences; and, occasionally, feelings of insecurity between students, facilitators and the curriculum (Mpofu et al., 1998; Schmidt et al., 2001). Whilst the benefits of the group process aforementioned indicate some of the value and potential of this aspect of the PBL curriculum design, the drawbacks noted represent serious concerns for a curriculum so heavily dependent on the small-group process.

The current literature review aims to document both promise and problems of the group process, although it does not offer solutions.

3.6.4 Facilitators

For the purposes of this review, the term "facilitator" is used to denote the overseer responsible for a group session. This is used synonymously with the term "tutor", which has equally been used in previous literature (Maudsley, 2003; Dornan et al., 2006). A myriad of roles are attributable to the facilitator, as shown in table 3.6, below.

Table 3.6 The roles of a PBL facilitator, according to Barrows (1988)

Advisor	Advocate	Administrator
Assessor	Career counsel	Caring
Challenger	Content consultants	Group leader
Instigator	Learner	Listener
Moderator	Monitor	Problem writer
Resource manager	Resource person	Role model
Sounding board	Stimulator	Supporter
Unit planner		

The previous literature reveals five prevalent issues with regard to facilitators: (a) expert versus non-expert facilitators; (b) facilitator training; (c) role changes from teacher to facilitator; (d) relationship changes between students and peers; and (e) changes in time commitments for the teacher-turned-facilitator. These issues are explained below.

Firstly, a discussion of "expertness" is problematic because of the varying degrees of expertise (Maflin, 2004). But for this discussion, facilitators will be considered either experts or non-experts. Facilitator expertise is a combination of content expertise and group leadership expertise, content expertise being further divided into subject knowledge and knowledge of the case at hand (Gilkison, 2003). Whilst being a "subject knowledge" expert in PBL is of limited benefit because of the multidisciplinary problem focus of the curriculum, experience with a particular case may itself name a facilitator an expert on that case. Indeed, it has been suggested that a facilitator can be considered an expert on a particular case after three supervisions of that same case (Zeitz and Paul, 1993).

There is a good deal of research on the topic of facilitator expertise, and the literature overwhelmingly supports the use of facilitators with expertise in content and tutoring, and with case experience, although there is tolerance for using facilitators without expertise (Barrows, 1985; Davis et al, 1999; Eagle et al, 1992; Martenson , 1993, Dolmans et al., 2002). Barrows (1988) asserts that the ideal situation is to have a content expert who is familiar with the case and who is also an expert facilitator. Failing that, the next best arrangement is to have an expert facilitator who is very familiar with the problem. This hierarchy continues down until there is a non-expert facilitator who lacks content expertise and is working with a new case, which would constitute the poorest arrangement possible.

There is evidence that first-year students are generally more satisfied with non-expert facilitators (non-expert faculty or advanced students) than are second- or third-year students – it is clear that as the students' sophistication increases, so does their need/desire for a more expert facilitator (Johansen et al., 1992). Within each year group, however, those with an expert facilitator, i.e. one who had facilitator training or experience, were significantly more satisfied, scored significantly higher on test questions and generated two or three times the learning issues, spending about twice as much time on the problem as those students with a non-expert facilitator (Davis et al., 1999; Eagle et al., 1992; Dolmans et al., 2002; Dornan et al, 2005). The hypothesis offered for this occurrence is that these expert facilitators were more able to provide support, cues or guidance when needed. In addition, expert facilitators asked questions at a more appropriate time, and the questions asked communicated more to the students. Almost certainly, an expert can form questions of greater value to the student (Davis et al., 1992). Eagle et al. (1992) find that a competent facilitator will stop at critical points to clarify, elaborate, allow silence, ask for justification, summarise, probe, and challenge, thus enhancing student-directed learning, listening, focusing and contemplation as well as the identification of learning issues and, therefore, the achievement of PBL course goals.

Despite the need for expert facilitators, several authors mention a lack of provision of facilitator training, and indicate recommendations for training ranging from formal, professional workshops to a simple observation-and-participation method (Davis et al., 1999; Tan, 2003; Dolmans et al., 2002).

Other issues with regard to facilitators include difficulty in changing role from teacher to facilitator (Engle, 1991; Des Marchais et al., 1992; Tan, 2003; Dolmans et al.,

2002) and in adjusting to new time commitments, which for a single facilitator are estimated at 10-20% higher for PBL than for the traditional curriculum (Neufeld and Barrows, 1974; and Pales and Gual, 1992). To cover the time commitment associated with PBL, many more facilitators would ideally be employed than would be the case for LBL. Due to the costs implied by this, faculty time remains a key limiting factor (Dolmans et al, 1993).

The final facilitator issue deals with the overwhelming changes in student-staff relationships when converting from LBL to PBL. Wilkerson and Hafler (1991), in a report of the unprecedented full-scale implementation of PBL at Harvard Medical School in 1987, discuss the need to involve teachers who had never thought much about learning nor worried about facilitating student interactions. The change from teacher to facilitator requires a redefinition of relationships between student and teacher, as summarised in table 3.7.

Table 3.7 The relationship of the facilitator and educational concern

Facilitator relationship	Educational Concern
Teachers' and students' learning	No longer simply knowledge disseminators; must trust students, guiding through questioning and giving feedback
Teachers and content	Should teachers cover everything, or should they let students choose what they need? Need to realise that a rich network of connections between ideas facilitates understanding and remembering
Teacher and student	Teachers partner with students in learning and relax control of content and learning process. Students learn to ask questions and provide extended explanations
Student to student	When working with problem material, students become actively engaged with one another, characterized by cooperation rather than competition
Teacher to group	Attentive to the needs of the group, fostering a cooperative spirit
Teacher	Self-awareness through a reflective process of asking self and answering thought-provoking questions regarding teaching method
Teacher and other teachers	Collaboration, vulnerability, modelling of the process of self-directed learning

In summary, facilitators are vital to PBL and have many roles to fulfil. Expertise, growth, training, changes in relationships and time commitments are all major factors influencing the facilitator's role. Wilkerson and Hafler (1991:579) note that

> "A facilitator's own self awareness and psychological sensitivity cannot be emphasized enough as ingredients in the mix that makes for a good learning environment – and so also as a central issue in faculty development."

3.6.5 Problem development

If PBL is the road to learning, and small-group tutorial is the vehicle of choice, problems fuel the vehicle on the road. According to Barrows (1985), problems should be structured to allow a learner to do whatever would be possible in the real situation:

> "Students must be able to ask the patient any question, perform any item of physical examination, or order any laboratory test in any sequence as they attempt to determine the basic mechanisms responsible for the patient's problems" (1985:16).

Problems may be statements, questions, or descriptions (Amin and Khoo, 2003), and can be presented to students in paper form, verbally, through reasoning or calculation, by 'signposts', in groups, individually, or laid out in some other medium, such as computer or drama. Students say that the clear, consistent relevance to professional work is what they value most (Davis, 1994). A problem's relevance can be measured by its fidelity, i.e. the degree to which it emulates real life situations (Davis et al., 1999; Wilkerson and Hafler, 1991; Coles, 1998). This relates directly to the theory of contextualized learning, which holds that learning is best served when done in the content it will be used.

Other principles for problem development and selection have been offered by Barrows (1994), who outlines six development principles that may be useful for problem development: (a) relevant problems; (b) multifaceted problems; (c) integrated problems; (d) consistent problems; (e) clinically current problems; and (f) motivating problems:

> "The principle of relevant problems illustrates the importance of considering incidence and significance of medical conditions. The first two addressed the need for diversity of learning opportunities, while three and four emphasized the relationship of cases to aims, content, and sequence of the PBL curriculum. Motivating problems has to do with open-endedness and student interest" (1994: 131-133).

A further factor for problem development is that of stories. As real life is told in stories, PBL problems are actually developed stories (Savin-Barden, 2000) structured for a specific form of delivery. The stories come from personal experience (Barrows, 2000), surveys or expert ideas about what is important for learners to know (Dolmans et al., 1993). Most case writers are experts in the field comprising the main topic of the story, and find story-writing an enjoyable and creative aspect of their work, and the broad goals of PBL allow case writers to "tell the story" as they know it (Barrows, 2000).

To write cases, field experts are joined by design groups consisting of medical practitioners, and a curriculum coordinator who provides educational expertise (Armstrong, 1991). The case writing process includes the following steps: development and planning, writing the case, case review, case use, and evaluation of the case after use (Wilkerson and Hafler, 1991). A popular case method in the medical field is revealed through a set of progressively distributed pages or sections of a problem (Armstrong, 1991).

Problems are designed with the idea that they will generate learning issues related to a particular medical topic. As useless problems cause difficulties for students in generating the appropriate learning issues (Azer, 2001), one way to determine the effectiveness of a problem is the degree of correspondence between the learning issues generated and the problems suggested by the learning issues.

Several studies use this "correspondence" approach to determine problem effectiveness. The average measure of correspondence for what are considered good problems is 60 %. Evaluation of problems using this "correspondence" between the problem learning issues and the students' learning issues, allows identification of problems not meeting their designed purpose (Albanese and Mitchell, 1993). Ensuring content coverage by introducing pertinent problems requires staff to select the appropriate number and types of problems in order to cover pertinent content areas.

To summarise, problems provide the focus for PBL programmes and serve to provide students with information that leads to self-identified learning needs. According to previous literature on PBL, it is critical that problems are of high fidelity and allow students to act as they would if encountering the problem in practice. The literature outlines the design of PBL problems, their role in the classrooms, and ways of evaluating problems.

3.6.6 Resources

One goal of PBL is to help learners identify and utilize resources (Barrows, 1985). There is evidence, based on faculty members' observations and studies (Coles 1998), that greater proportions of PBL students use the library more frequently and for longer periods of time than do students in conventional schools. According to Golby and Parrott (1999), students in a PBL curriculum at the Bowman Gray School of Medicine use library resources five to ten times more than the LBL students. High resource-use affects the library's collection, instructional programme, facility, staffing and budget (Azer, 2001) as well as the resources available for the support of lectures and non-PBL students. If a school were to make a wholesale switch to PBL, as Harvard's New Pathway did in 1987, severely limited resources may impact the school and students in a critical way.

A standard problem-design format lists, at least partially, the learning references and resources associated with the problem or programme (Golby and Parrott, 1999; Armstrong, 1991). Many authors (for example Azer, 2001) create their own resources, often using the original lecture material, or gathering or creating learning resources from printed materials, audiovisual formats, models, and specimens. Other resources are often provided to facilitators in the form of guides and forms.

Computer resources play an ever-increasing role in the PBL curriculum, from problem simulation to information retrieval. Having developed a rationale and method for the introduction of computer support for collaborative learning (CSCL) into the PBL curriculum, Koschmann et al. (1997) hypothesize that CSCL could serve as the blackboard, case data-base, group dynamic organiser, communication port for human and non-human resource, and case builder structural organiser. Thus far, however, literature on PBL is void of models that make use of such a system.

3.6.7 Cost

> "It is widely assumed that small-group PBL is more expensive and consumes more faculty time than conventional medical education" (Menin and Martinez-Burola, 1986:208).

A major factor in the implementation of PBL is the cost, caused by increased teaching time to small groups as opposed to the larger classes associated with LBL, as well as by other responsibilities required by the PBL process. It is therefore assumed that more faculty members are needed.

However, in a comparison of LBL teaching time with that of PBL, Menin and Martinez-Burola (1985) conclude that there are no differences in the total amount of teaching required by both PBL and LBL, even for schools with large classes. Yet these findings are in contrast with those of Donner and Bickley (1990), who conclude, after comparing the costs (in faculty time) of PBL and LBL in a pathology module, that the PBL curriculum is quite feasible for schools with classes of 60 or fewer students. This assumption is based on the fact that the cost of LBL increases directly with the number of lectures presented, whilst the cost of a PBL programme increases directly with the number of students. The cost per student of LBL therefore shows a sharp decrease when student admission increases, with 100 LBL students costing roughly the same as 40 PBL students. However, the differences lie in how teachers spend their teaching time. In PBL, teaching staff spend the majority of their time in contact with students, while in LBL they spend more time on preparation than in contact with the students.

Comparisons were made between the seven medical faculties in the Netherlands following the PBL programme, in terms of cost and outcome. The results show that the students of Maastricht University need less time to graduate, perform better in professional skills and have greater appreciation of their (PBL) curriculum than do those following LBL curricula. Consequently, this study supports the notion that PBL is a cost-effective and attractive model of teaching (Azer, 2001). However, there is need for further investigation of the cost issue, for the purposes of cost-effective PBL implementation, appropriate allocation of facilities and resources, and management of staff and the teaching load, in order to achieve the most effective PBL programme.

3.7 Theoretical foundations of problem-based learning

The major theoretical foundation of PBL is derived, in part, from research on education and cognitive science (Albanese and Mitchell, 1993). Theories are here reviewed in an attempt to understand them as they relate to the form and function of the PBL curriculum.

Koschmann et al. (1997) outline a set of six principles they say "provide some guidance for what is necessary for promoting effective instruction" in any curriculum. These principles, taken together, comprise most of the instructional goals within the PBL curriculum design:

1. Principle of Multiplicity: Knowledge is complex, dynamic, context-sensitive and interactively related; instruction should promote multiple perspectives, representations and strategies.

2. Principle of Activeness: Learning is an active process, requiring mental construction on the part of the learner; instruction should foster cognitive initiative and effort after meaning.

3. Principle of Accommodation and Adaptation: Learning is a process of accommodation and adaptation; instruction should stimulate ongoing appraisal, incorporation and/or modification of the learner's understanding.

4. Principle of Authenticity: Learning is sensitive to perspective, goal and context; instruction should involve activities, settings and objects of study that are authentic.

5. Principle of Articulation: Learning is enhanced by articulation, abstraction and commitment on the part of the learner; instruction should provide opportunities for learners to articulate their newly-acquired knowledge.
6. Principle of Timelessness: Learning of rich material is timeless; instruction should instil a sense of tentativeness with regard to knowing; a realisation that understanding of complex material is never "completed", only enriched; and a life-long commitment to advancing one's knowledge.

Norman and Schmidt (1992) suggest that the theoretical base of PBL emerges from research on cognitive psychology – specifically on memory, problem solving and "case-based" reasoning – and from research on concept formation and categorization. They say that PBL promotes three functions: (a) acquisition of knowledge in the context in which it will be used; (b) mastery of concepts to be applied to new problems; (c) acquisition of prior examples. Briefly explained, acquisition of knowledge in context emphasizes the importance of activating prior knowledge, elaborating at the time of learning (through discussion, note-taking, answering questions, or applying knowledge to practice), and matching the learning context to "real" situations that students will encounter. Mastery of concepts means that the problem must be approached without much foreknowledge of the domain or underlying principle, and that the problem solver must receive corrective feedback about her solution immediately upon completion.

3.7.1 Benefits of problem-based learning: real and/or perceived

There can be little doubt that some PBL authors tout the benefits of this system with a biased vigour and little shame about the lack of research data available to substantiate it. Table 3.8 presents some of the supposed benefits found in the literature, which relate directly back to the theory, goals and objectives of PBL, promoting it as a promising alternative to LBL. This study brings light to the actual benefits of PBL (see Chapter Seven for the results summary).

Table 3.8 The real and/or perceived benefits of PBL

Objective	References
Activates prior knowledge	Norman & Schmidt, 1992; Coles, 1998; Harden, 1996
Allows interactions	Lovie-Kitchin, 1991; Dolmans et al., 1996; Harden,1996
Applies new knowledge	Donner, 1990; Azer, 2001
Assists elaboration	Coles, 1998; Colliver, 2000
Attracts higher-quality students	Des Marchais et al., 1992
Builds communication skills	Boud & Felleti, 1991; Donners, 1990; Azer, 2001
Builds team work skills	Mpofu et al., 1998; Johnson and Johnson, 1987
Creates knowledge ownership	Norman & Schmidt, 1992
Develops meta-cognitive skills	Barrows, 1994; Coles, 1985b
Develops skill of inquiry	Boud & Felleti, 1991, Coles, 1985b
Encourages cooperation	Dolmans et al., 1996; Khoo et al, 2001
Forces organisation of time	Des Marchais et al., 1992
Forces reflection	Boud and Felleti, 1991; Coles, 1998; Jayawickramarajah, 1996; Margetson, 2000
Forces self-study skills	Barrows, 1994; Coles, 1985b
Increases motivation	Norman & Schmidt, 1992; Coles, 1998
Instils active learning	Coles, 1985b
Involves more emotions	Bayard, 1994
Maintains proactive learning	Coles, 1998
Produces better grades	Pales & Gual, 1992
Promotes critical thinking	Morrison and Murray, 1994; Maudsley et al., 2000
Promotes knowledge retention	Norman & Schmidt, 1992; Coles, 1998; Albanese, 2000; O'Neill et al., 2002
Requires subject integration	Mowat, 1999; Alleyne et al., 2002
Responds to change	Boud & Felleti, 1991; Tosteson et al.,1994
Supports nurturing	Albanese & Mitchell, 1993
Supports relevance	Coles, 1998; Azer, 2001

3.8 Meta-analysis of problem-based learning

There are seven meta-analysis reviews available with regard to PBL evaluative research. The first, by Albanese and Mitchell (1993), analyses the effectiveness of research on PBL. Secondly, Vernon and Blake (1993) review literature covering years of PBL research which: "1) recapitulate[s] all accessible data that compare PBL with more traditional methods of education and 2) examine[s] distinction in these data by common meta-analytic techniques, and 3) appraisal[s] of the apparent strengths and weaknesses for research in this field" (Vernon and Blake, 1993:550). These and five more meta-analysis reviews are discussed below, covering literature published before 2003 that concentrates on the effectiveness of PBL.

In their meta-analysis of sixty-six PBL studies published in the English-language international literature from 1972 to 1992, Albanese and Mitchell (1993) compare PBL and LBL on twelve factors thought to be important indicators of a good medical education. The authors considered the following factors relevant for the study: (a) educational level of participants in the study (year in the programme); (b) scope of the intervention; (c) study design type; (d) numbers of participants in PBL and LBC interventions; and (e) specifics regarding the outcome measure used. These factors, the number of studies considered, and a brief summary of their analysis include:

1. Basic science examination performance (10 studies): LBL generally higher than PBL (in six of the ten studies; three of these were significant, with p-values of 0.05).
2. Clinical science examination performance (7 studies): PBL generally better than LBL (in five of the seven studies, although only one significantly).
3. Thought processes promoted (3 studies): PBL teaches and uses backward reasoning, thus risking erroneous reasoning that would then need to be corrected.
4. Study behaviours promoted (6 studies): PBL students study for understanding or to analyse what they need to know, and tend to make more use of library resources.
5. Learning environment promoted (4 studies): Kellner Symptom Questionnaire showed PBL students to be substantially less stressed. PBL students generally rated their experience higher than LBL students in terms of meaningfulness, flexibility, emotional climate, nurturance and student interactions.

6. Students' satisfaction, selection and retention (10 studies): PBL found to be engaging, challenging, useful and enjoyable; LBL found to be irrelevant, passive and boring.
7. Graduates' perceptions of their preparation (6 studies): PBL graduates view the quality of their training more positively than LBL in humanistic areas, clinical reasoning and preventive care.
8. First choice of residency: (2 studies): 79% PBL vs. 59% LBL in one, and 90% PBL vs. 71% LBL in another.
9. Clinical ratings of graduates & undergraduates (7 studies): clear trend towards higher ratings for PBL by supervisors.
10. Performance assessments of graduates (3 studies): generally good for PBL but worries regarding incomplete cognitive framework would likely cause more referral to specialists, resulting in a higher cost per patient.
11. Specialty choices and practice characteristics (8 studies): general trend for PBL students toward family practice, but some concern about the likelihood of a solo practice because of group experience.
12. Faculty members' satisfaction (8 studies): faculty find PBL a satisfying way to teach, due to the personal contact involved in small groups.

The results of this meta-analysis indicate that PBL instruction is significantly superior in programme evaluations that examine educational atmosphere, curricula and individual courses. Furthermore, attendance tends to increase, whilst stress among students appears to decrease. Results show PBL students not to differ greatly from LBL students when tested on knowledge, but indicate that traditional students perform better in the National Board of Medical Examiners Part I (NBME I) in the United States. The authors conclude that the results support the superiority of the PBL method over more traditional methods.

The results further indicate a small but significant trend in which clinical examinations favour PBL graduates. PBL students participating in the study were more likely to enter family medicine and reported feeling more nurtured. Overall, both staff and students felt more satisfied with their teaching-learning experiences than did LBL staff and students. On the other hand, however, some PBL students scored lower on basic science examinations and felt they were less prepared in the basic sciences than non-PBL students. The study found that PBL graduates engaged in backward reasoning rather than forward reasoning, and revealed gaps in their cognitive knowledge base.

Following these findings, Albanese and Mitchell conclude that more research is needed before an absolute and unqualified approval of PBL can be made:

> While weaknesses in the criteria used to assess the outcomes of PBL and general weaknesses in study design limit the confidence one can give conclusions drawn from the literature, the authors recommend that caution be exercised in making comprehensive, curriculum-wide conversions to PBL until more is learned about (1) the extent to which faculty should direct students throughout medical training, (2) PBL methods that are less costly, (3) cognitive-processing weaknesses shown by PBL students, and (4) the apparent high resource utilization by PBL graduates (1993: 1).

In a review of all available research published between 1970 and 1992 that compares PBL with more traditional methods of medical education, Vernon and Blake (1993) find 35 studies representing 19 institutions with health-related educational programmes containing significant PBL emphasis. The five separate sources they use for their meta-analysis include: (a) ERIC and MedLine; (b) prior literature reviews; (c) personal communications with investigators; (d) research report bibliographies; and (e) journals that were likely to publish PBL evaluations. Using effect-size and supplementary vote-count, Vernon and Blake carried out five separate meta-analyses:

1. Students' Programme Evaluation (12 studies): PBL superior without exception on attitudes, opinion of faculty, class attendance, mood and stress.
2. Academic Achievement (8 studies using the National Board of Medical Examiners Part I): effect size favours traditional curriculum, while vote count showed no difference. In 7 further studies on factual knowledge tests other than NBME I, a trend was observed favouring traditional curriculum, but was not statistically significant.
3. Learning Process (2 studies on learning approach): both studies suggested PBL students use more "meaning" than "reproducing" and LBL more "reproducing" and less "meaning". In 4 further studies, on learning

resources used, PBL students used a greater degree of independent study than traditional students.

4. Clinical Functioning (12 studies comparing PBL to traditional): PBL significantly better statistically on clinical performance.
5. Clinical knowledge (4 studies): slight but non-significant trend favouring PBL.

Vernon and Blake conclude that their results support overall the supremacy of the PBL, but they are less than fully conclusive:

> The present meta-analysis of evaluative research indicates that it is unlikely that students will suffer detrimental consequences from exposure to PBL programmes...The analysis highlights the need for methodologically rigorous studies that further address the value and effects of PBL" (1993: 561).

In summarising these first two PBL meta-analyses, by Albanese and Mitchell (1993) and Vernon and Blake (1993), Wolf (1993:544) states:

> The cumulative message after years of research is not definite. Uncertain results suggest there may be a problem with the way PBL is being studied. Two factors concerning the PBL literature are (a) the research being done by PBL practitioners who necessarily have bias tendencies, and (b) strictly quantitative research being used which decomposes and decontextualises the curriculum and does not consider the robust relationships within the PBL curriculum design.

The implications and recommendations most strongly supported by the results of these first two reviews are as follows: (1) there is a paucity of good-quality studies and evidence available regarding the hypothesis that PBL produces learning and/or learners different from or superior to those derived from traditional approaches; (2) results are often incomplete and poorly reported in the existing primary research reports; and (3) there is tremendous need for well-designed, creative primary research-evaluation studies that examine important, clinically relevant behaviours and outcomes.

The third review to be discussed here is that of Berkson (1993), who also conducted a meta-analysis of the literature on the effectiveness of PBL. Berkson's analysis purports to establish whether or not PBL is fulfilling its promises, outlined in a series of seven questions:

1. Do PBL curricula teach problem solving better than traditional curricula? To date there is no such evidence.
2. Do PBL curricula impart knowledge better than traditional curricula? Superiority of PBL over traditional curricula cannot be assumed without a better understanding of how type, number and sequence of problems affect learning.
3. Do PBL curricula enhance motivation to learn medical science better than traditional curricula? Motivation is hard to measure and PBL is not unique in its capacity to stimulate curiosity nor is it immune to factors that inhibit interest. No one has yet convincingly measured and compared the interest of a PBL student with that of a traditional student.
4. Do PBL curricula promote self-directed learning (SDL) skills better than traditional curricula? Post-graduate practice of SDL strategies may prove more dependent on the proximity of available resources, peer expectations, role models, the physician's practice profile and time constraints than on "putative" skill previously acquired or refined in a PBL or traditional curriculum.
5. Why does the product of a PBL curriculum seem indistinguishable from traditional curriculum? PBL and LBL products look the same at the end of the programme because of curriculum commonalities; students, texts, clinical practice, licence exams and faculty all homogenize the outcomes.
6. Does PBL promote more student and faculty satisfaction than LBL? PBL students have difficulty with ambiguity of learning objectives and the need to prepare for licensing exams. Faculty complain about suppressing their expertise and competing academic expectations and time commitments.
7. Does PBL cost more than LBL? Hard to determine but could be daunting for schools with a large number of students or small schools on a tight budget.

Berkson also expresses concern that the PBL student cannot be distinguished from his or her traditional counterpart; that the PBL experience can be stressful for both students and staff; and that PBL can be unrealistically costly to implement. Yet despite this, Berkson does also state that PBL students demonstrate greater engagement in learning, are more self-directed, and have higher levels of satisfaction with their course work. In that a PBL graduate is not distinguishable from a traditional graduate, Berkson concludes that PBL has not fulfilled its expectations, but considers that those expectations were probably unrealistic to begin with. She proclaims that concern over principles of learning and teaching methods are the strong points of PBL, and that its central weaknesses probably lie in its non-expert facilitator and cost issues. While the two curriculum approaches seem dichotomous, Berkson believes that in the years to come, environmental and accreditation pressures will likely force both curriculum designs to become more alike.

A fourth meta-analysis study was conducted by Van Den Bossche et al. (2000). Here, the study design and quality criteria applied to the primary studies appear to be fairly nominal, increasing the likelihood that studies with significant weaknesses in terms of partiality minimisation were included in the review. The authors recognised the danger of partiality in the setting of studies and described what was, by the standards of most reviews, a fairly comprehensive search strategy. However, the search strategy included only a limited number of bibliographic databases and terms, and would therefore also appear to be inadequate in these respects (Egger & Smith 1998).

A couple of years later, Smits et al. (2002a) carried out an evaluation of the efficiency of PBL in continuing medical education. An explicit search strategy including a wide range of bibliographic databases was used, but it appears that limited attempts were made to locate the so-called 'grey' literature. This analysis adopted strict methodological inclusion criteria by including only randomised and controlled trials. Whilst this will have reduced the risk of partiality in the individual studies, it may also have meant that potentially useful studies of PBL using other designs were excluded. In contrast to the findings of other researchers and of their own expectations, Smits et al. conclude that there was no fixed evidence indicating the superiority of PBL compared to other educational methods as regards knowledge and performance, according to their own taxonomy of PBL.

Having reviewed 8 studies on PBL (not using meta-analysis), Colliver (2000) concludes there to be "no convincing evidence that PBL improves knowledge base and clinical performance" (2000: 259), but agrees that it may provide a more enjoyable approach to medical education:

> "PBL may provide a more challenging, motivating and enjoyable approach to medical education but its educational effectiveness compared to conventional methods remains to be seen" (2000: 266).

Newman (2003) responds to this by identifying the need for a systematic review and meta-analysis of the existing research evidence, following a study asking whether or not PBL results in increased participant performance when compared to other approaches. The development and piloting of such a study by a group of researchers convened under the Campbell collaboration, which followed specific criteria and guidelines for identifying relevant studies and synthesized the results both qualitatively and quantitatively in order to provide potential evidence. PBL was used in higher education programmes for health professional education at both pre- and post-registration levels; the pre-registration students of medicine were the majority reported.

From the five meta-analyses studied by Newman, 91 citations were identified, of which 15 met the criteria. Of these 15, only 12 were reported to have extractable data. A summary of the findings for these 12 citations follows:

1. A small number of effects were reported on 'impact on practice' and on 'approaches to learning'.
2. The data that was extracted from the papers gave very little information about the design, preparation or delivery processes of either the PBL intervention, or of other educational methods to which PBL was being compared.
3. A range of measurement instruments were used and various outcomes observed in the studies that reported 'effects on practice'.
4. In the 'attitudes to practice' study, the effect sizes found favoured PBL.
5. Two studies reported effects on 'approaches to learning'. These used a range of instruments and reported five effects. In both studies, the results favoured PBL on all the scales.
6. The PBL groups had fewer of the undesirable and more of the desirable 'approaches to learning' after the intervention.

7. It was reported that there were sufficient effects to justify an attempted meta-analysis.
8. Sensitivity analysis suggested that study design, randomisation, level of education and assessment format are all potential moderating variables, but the results were not conclusive.
9. Only one study reported effects on 'satisfaction with the learning environment' that met the review inclusion criteria.
10. The study in an undergraduate medical education programme required students to rate their experience on a series of scales.
11. The largest effect size in favour of PBL was the students' rating of innovation.

Newman (2003) concludes that the term 'PBL' is issued in relation to a wide range of practices, and that the descriptions of the PBL and the control (LBL) group were not enough to highlight the main features of the approaches used. Having found that some results favoured the PBL group whilst others favoured the control group, then further recommended the need for a consistent report of the main characteristics of the PBL methodology used in a particular study, stating that since most of the reviews do not provide enough evidence to support the wide use of PBL without further research, there should be a system and research plan for the evaluation of the studies.

The last meta-analysis to be discussed here is that of Dochy et al. (2003). This study reviewed 43 articles demonstrating that PBL has a positive effect on participants' ability to apply knowledge.

Dolmans et al. (2005:737), however, point out weaknesses of Dochy's and other studies conducted since 2000:

> "These studies conducted since 2000 focused mainly on comparing conventional and PBL curricula and measuring the outcomes or effects of PBL. The weakness of these reviews is that they do not focus on theoretical claims behind PBL, due to which they do not provide us with better insights into why not PBL might work under which circumstances"

In all, the seven meta-analyses discussed above provide different results based upon an attempt to "let the research speak." Each analysis draws from basically the same literature base and the message is mixed. Furthermore, these meta-analysis reviews have no convincing evidence that PBL strategies are superior to other educational strategies. Furthermore, one strong and consistent theme appears to be the need for further research using suitable designs and focusing on the link between theory and practice.

The purpose of the current study is to participate in and respond to this ongoing debate.

3.9 Comparison of problem-based learning and lecture-based learning

Here a review of previous literature studying problem-based and lecture-based learning will aid a comparison of the two methods.

Firstly, Newman (2003) evaluates an experimental study of the effectiveness of PBL in a continuing education programme for nurses from 6 London hospitals in the United Kingdom. This study involves a randomized control trial comparing PBL with LBL teaching methods in terms of assessment results, student satisfaction, student workload, teacher workload, approaches to study, assessment of teamwork and communication skills and assessment of changes in practice including post-course follow-up. The results indicate a lower level of satisfaction among students in the PBL curriculum than among those in the traditional curriculum; the dropout rate was also ten times greater than those in the control curriculum and did not appear to meet students' expectation on learning, teaching or their role as a student.

A study by Claessen and Boshuizen (1985) summarises the problem-solving skills of students from a traditional school and compares them with the problem-solving skills of PBL students. In this study, each student was asked to read, process and write a differential diagnosis of information contained in case histories. Small but reliable differences were found in favour of the PBL students.

Bligh (2000) also reports higher scores among PBL students in problem solving, team working, and motivation, but finds the students more anxious regarding clarity of objectives and standard of work required. A study of nursing students by Morales-Mann and Kaitell (2001), on the other hand, revealed that PBL "produced clear benefits for students, such as increased autonomous learning, critical thinking, problem solving, and communication" (2001:13).

Elstein et al. (1978) also address problem solving at length, querying whether there is a general skill of problem solving that physicians develop to apply to medical decisions, or whether there is a specific medical problem-solving process. The results of a five-year study show that problem-solving methods are similar across disciplines, but that medical students may have more opportunity to practise problem solving during their clinical experiences and, therefore, are more likely to develop the skill.

On this matter, it has been suggested that, although the hypothetico-deductive method may be used by novice problem solvers, this is not the method used by experts and is generally thought to be weak (Patel et al., 1990). Evidence suggests that expert problem-solvers become experts not only by practising a certain skill of problem solving, but by the attainment of relevant knowledge to accompany practice, using cognitive structures. These cognitive structures have been termed "illness scripts" containing a "wealth of clinically relevant information about disease, its consequences, and the context under which illness develops" (Schmidt et al., 1990).

If, however, claims that problem-solving skills are derived from practice are correct, and if it is also true that students in a PBL curriculum start problem solving earlier, it seems that PBL graduates would have better problem-solving skills than graduates from traditional medical schools. This proposition will now be explored.

In one study, which reviews the performances of students from two different medical schools (one with a PBL curriculum and one with an LBL curriculum), students were asked to explain how a metabolic deficiency and a specific disease could be summed up. Students from the PBL curriculum appeared to take an analytical approach to the problem by first considering the biochemical aspects, and later linking them to the clinical aspects of the problem (Jayawickramarajah, 1996). Students in the conventional curriculum, however, tended toward a more memory-based approach, resulting in less accurate answers. It was thus deduced that students in a PBL curriculum are more likely to retain knowledge as they seek solutions to problems than students following a conventional curriculum (Schmidt et al., 1990; Mennin et al., 1993; Vernon and Blake 1993). Claessen and Boshuizen (1985) attribute this improved ability to retain knowledge to the PBL students' extra experience in working with patient problems.

3.9.1 Teaching content

Having looked at student performance and problem-solving skills, it follows that we focus on the teaching content and methods used to achieve these ends.

The question "Do PBL curricula teach course content better than LBL?" may be no different to the question "Do PBL curricula teach problem solving better than LBL?" – it may be that these two issues cannot be considered or answered separately. In order to answer these questions, those studies will be considered which involve differences in examination performance between PBL students and those following a more conventional curriculum students, on the assumption that this is an accurate measure of course content and teaching.

To start with, data comparing graduates from the McMaster Medical University PBL programme with all other graduates of Canadian Medical Schools show comparable performance on the Canadian qualifying examination. These qualifying examinations are multiple-choice, similar to the licensing board examinations in the United States. McMaster graduates of the seventeen graduating classes since 1972 averaged 89 % on their first-attempt, with an 89-96 % first-attempt pass rate for all graduates (this figure includes those following PBL and those following other curricula) (Neufeld, Woodward et al., 1990).

Santos-Gomez et al. (1990) further study the performance of PBL graduates. Here, data from 130 students was collected in order to evaluate, among other variables, perceptions of the students' knowledge by supervisors, nurses and peers. Following comparisons between PBL and LBL graduates, Santos-Gomez et al. indicate that PBL students score higher in supervisor- and self-ratings on all categories, but lower than LBL graduates when rated by nurses (Santos-Gomez, 1990).

Studies recapitulating students' scores on single tasks produce varying results. In one study, students were asked to choose between a PBL approach and a traditional approach for a four-week curricular segment on haematology (Eisenstaedt et al., 1990). Volunteers received PBL methods of instruction and non-volunteers received the traditional didactic course. In a final evaluative examination, test scores showed a lower score overall for the PBL students. However, in a follow-up examination administered two years later, the control group scores had dropped quite significantly to almost the same level as the PBL group scores, whilst PBL scores remained at almost the same level and therefore almost equal to LBL results obtained at the same time (Eisenstaedt et al., 1990).

Also in order to evaluate and compare performance, Verwijnen et al. (1990) collected progress test scores from six classes (one from each year of the six-year curriculum) at the University of Limburg, the only non-traditional medical school in the Netherlands, and compared them with the scores of students from the other medical schools in the Netherlands. This progress test was an achievement test given periodically to all students at Limburg to evaluate their progress as well as to evaluate the curriculum. Scores for Limburg students were somewhat lower than those from two of the other schools at three measuring points, but by the sixth year the differences had disappeared.

3.9.2 Self-Directed Learning (SDL)

Many medical educators have said that there is need for physicians with self-directed study skills (Neame and Powis, 1981; Barrows, 1994; Muller, 1984; Tosteson, 1994). When PBL was introduced, emphasis was placed on the purported benefits of students cultivating problem-solving skills, and of improved course content (Barrows and Tamblyn, 1980; Barrows, 1996). With disappointing results in these two areas, however, emphasis shifted to activities that would foster self-directed learning (SDL) skills (Neufeld et al., 1989).

In 1984, a panel convened by the Association of the American Medical Colleges to evaluate the professional education of physicians presented a report recommending the adoption of evaluation methods to identify those students who can learn independently and to provide resources to (i) enhance this ability, and (ii) foster independent learning in those students who were identified as less capable in this area. The stated reason for this was to allow physicians to keep abreast of new scientific information and new technology in a rapidly changing scientific arena (Muller, 1984).

Tosteson (1994:235) elaborates on the necessity of producing physicians with SDL learning capabilities:

> "The strongest forces for change in medicine are the discoveries that are transforming our ideas about human biology and our place in nature. New insights in the natural sciences, particularly molecular and cell biology and astrophysics, are moving us toward a new philosophy of health and disease and every other aspect of our existence. Scientific discoveries are also altering medicine in a more immediate and palpable way, by informing the development of new forms of technology. The trend is accelerating and will require that physicians master an ever more specialized body of knowledge in order to make skilful use of the new technology."

Neame and Powis (1981) report on their work at Newcastle University Medical School, New South Wales, where curriculum revisions were required that would teach students to be responsible for and to structure their own learning. Their analysis of the learning process reveals the following six important issues for independent learning, which were addressed through the integration of tutoring sessions with no more than eight students per tutor (Neame and Powis, 1981: 886):

1. Individuals must be able to recognize areas of deficiency in their knowledge and be sufficiently motivated to seek to remedy such deficiencies.
2. They must perceive and recognize appropriate triggers or cues that initiate and orientate their studies.
3. Individuals must define the scope of their study by generating specific questions to be answered.
4. They must seek and gather relevant data and information from available resources.

5. They must evaluate critically the data in terms of validity and relevance to the questions asked.
6. Finally, the individual must integrate the newly derived knowledge with their existing knowledge.

Through the habit of continuous self-evaluation and self-education, it is claimed that PBL students find out how to learn and analyse their own thinking, ideas, logic and data analysis, and watch others do the same, in what is known as a cyclic reasoning process. However, while PBL facilitates the constructs of SDL, this is no guarantee that students will become expert self-directed learners. In fact, previous literature reports mixed results of the effects of PBL on SDL.

In addition, SDL is ill-defined and, therefore, difficult to measure. Marton et al. (1984) suggest that definition may be possible by observing how students study, in order to infer the learning processes that are operating and, in turn, determine the quality of what is learned. Thus in a qualitative study of student-directed discussion in four PBL tutorial groups, Wilkerson, Hafler and Liu (1991) identify five themes important in characterizing the extent to which students direct their own learning: (a) initiation of topics; (b) style and pattern of facilitator talk; (c) use of questions; (d) pattern of student-facilitator interaction; (e) presence of pauses and interruptions. This study is significant in defining the elements most useful in building a model of SDL.

Two further observations prevalent in the literature relating to SDL warrant mention. Firstly, students overwhelmingly report that, whilst they need to study harder, they are more motivated to do so when following a PBL curriculum (Barrows, 2000). Secondly, many authors allude to a need to provide more direction and structure early in the PBL experience, gradually allowing more self-direction as learners progress (Barrows, 2000). Of these two observations, the former provides justification for the implementation of PBL in relation to SDL, while the latter provides insights on how to develop SDL once PBL is implemented.

Whilst Fish and Coles (2005) claim confidently that PBL fosters independent learning, an effective evaluation method to test such claims is lacking (Schmidt et al., 1987). Furthermore, whilst students say that they have cultivated self-directed study skills (Woodward et al., 1990), and it has in fact been shown that students in a PBL curriculum do employ more outside learning resources than students in an LBL curriculum (Azer, 2001), it remains to be seen whether or not all of the anticipated benefits of PBL in fostering self-directed learning (SDL) will be realised. Clearly, further and more long-term research studies are needed in relation to this issue.

3.10 The use of PBL as a methodology to provide the human genetics component in medical education

Barrows and Tamblyn (1980) were among the first to describe the application of PBL methodology to the teaching of human genetics within medical schools (1976). It was not until nearly five years later, however, that other literature on this topic began to appear in reference books and medical journals. Even so, the amount of such literature has been extremely sparse.

Adkinson and Volpe (1994) examine the impact of increasing student exposure to medical genetics through a problem-based curriculum during the first two years of medical training at Mercer University School of Medicine in Georgia, which was the first medical school in the United States to utilize PBL as the sole educational method through which students learn the basic sciences. When comparing Mercer's PBL curriculum with other schools' curricula, they report that it more than tripled the number of hours spent by students discussing concepts of genetics in a formal setting, and that not one of Mercer's students chose to drop the genetics modules during his or her first two years of medical education. Adkinson and Volpe conclude that Mercer students "are being challenged to view the genetics of a patient as importantly as any other presenting feature" (1994: 1).

The use of PBL for teaching about genetics to medical students was stimulated by the report 'General Professional Education of the Physician' GPEP (Muller, 1984), which may be summarised as follows:

> "Faculties should emphasize the acquisition of skills, values and attitudes by students at least to the same extent that they do the acquisition of knowledge; this requires limiting the facts that students are required to memorize. Education should be flexible in order to accommodate changing demography and modifications in the

health care system. Students should be encouraged to set attainable educational goals and to learn independently; faculties should provide opportunities and unscheduled time to further the development of those skills. Educational experiences should require students to become problem-solvers rather than passive recipients of data, and basic science and clinical education should be integrated to enhance learning of the basic principles and to promote their application to solving clinical problems" (1984: 128).

Questions arising about the extent to which these objectives are consistently met within PBL curricula have been addressed in a variety of ways, some of them more satisfactory than others in answering the general evaluation question 'Does PBL work in medical education?'

3.11 The relevant literature base in Saudi Arabia

As we have seen, medical schools all over the world have been influenced by developments in medical school curricula, resulting in the emergence of problem-based instructional methodologies. Within the Middle East specifically, three PBL medical training programmes have been formed, at Al-Jazera University in Sudan, the Arabian Gulf University in Bahrain and Suez Canal University in Egypt. The PBL method has not yet been employed in the country of Saudi Arabia, however.

Examining the use of PBL in Middle Eastern medical training, Saudi Arabian medical educators Al-Sebai et al. (1982) ask whether a single curricular model is appropriate for Saudi medical education and, if so, whether the model should be "traditional" or "more innovative". They conclude that the Saudi curriculum needs to move towards innovative methods in order to be comparable to other countries.

There have been no previous studies, however, contrasting the outcomes of different teaching models in the medical education programmes of Saudi Arabia, and certainly none focusing on the incorporation of genetics knowledge into Saudi medical curricula. The current study aims to fill this gap, as detailed in Chapter Two, through a comparison of PBL with the lecture-based case (LBC) teaching method at four colleges of medicine in Saudi Arabia (see Chapter 2.5, 'Research Question').

3.12 Summary

In this chapter, PBL has been looked at from a different perspective. The literature has been reviewed to answer a variety of questions asked about PBL, such as:

- What are the characteristics of PBL?
- Where and how has PBL already been implemented?
- How should PBL be evaluated?
- What has been found about the impact of PBL approaches?
- Is there any relevant literature about Saudi medical education with regards to PBL?
- What is the place of human genetics in PBL methodology?

Both quantitative and qualitative studies report benefits of PBL among students and practitioners, the vast majority of these in medical education. This study will delve further into an analysis of these benefits, aiming to discover whether Saudi students receiving PBL instruction are ultimately better-prepared to think critically and ask better assessment questions than students who are taught using the lecture-based textbook and lecture method. Evaluation of PBL is essential, in order for the faculty at the Saudi medical colleges to have the evidence necessary to determine whether or not this method should become institutionalized, i.e. move from being a novel experiment and gain a permanent status.

With the support of previous literature on medical education, the above questions have been addressed within this chapter; research question described in Chapter 2.5 remains to be answered:

- What is the impact of the Problem-Based Learning (PBL) curriculum on undergraduate medical students in Saudi Arabia?

The next chapter covers the research methodology and design used in this study, incorporating both qualitative and quantitative research approaches in search of answers to this question.

Section III: Process of Empirical Study

Chapter Four

Research Methodology

Chapter Four
Research Methodology

4.1 Introduction

Wellington has described methodology as the "activity or business of choosing, reflecting upon, evaluating and justifying the methods you use" (1996:16).

In the current study, the research approach involved a descriptive case-study methodology embedded in an experimental design, the case study being based around the "bound system" (Merriam, 1990: 28-29) of a genetics module taught using PBL teaching methods.

The study involved two treatments, or curricular interventions, in the aim of examining in depth the benefits and problems involved in introducing to medical education the teaching methods of PBL (Problem-Based Learning) and, more specifically, CPBL (Closed Problem-Based Learning), comparing these benefits and problems with those of the more traditional LBC (Lecture-Based Case) approach. CPBL and LBC each represent an extreme of Barrows's (1986) problem-based learning taxonomic model.

Students participating were randomly assigned using a computerised random-number generator to groups that would each be taught using either PBL or LBC methods. Each group was divided into pre-clinical and clinical levels, to which two treatments were applied. These treatments included a human biochemical disorder (HBD) and a human chromosomal disorder (HCD), which are the first two modules of the human genetics unit and thus represent the point in the current (LBL) curriculum where information about genetics is introduced.

The research was carried out in Saudi Arabia, a country where recent experiments with PBL within undergraduate medical education are in need of evaluation. As the human genetics unit is essential for an understanding of disease generally and in Saudi Arabia particularly (Al-Muhanna & Bella, 2006), this was used as a case subject in which to examine the different teaching methods. The unit selected consisted of two 2-hour sessions per week over a 4-week period, divided into two modules, the first relating to biochemical disorders (HBD) and the other relating to chromosomal disorders (HCD). Half the students were taught using a closed-loop problem-based method (CPBL) and the other half using a lecture-based case (LBC) method.

The initial remit for this research was with one university, focusing on 64 pre-clinical and 152 clinical undergraduate students in their medical college. During a briefing of the Saudi Deans' Council (SDC), however, three other universities became very interested in the research. Consequently, subjects for the study now include undergraduate students in the pre-clinical and clinical phases of the medical courses at four medical colleges in Saudi Arabia, as shown in table 4.1. Four hundred and eighty-four students took part in the research, of which 232 were at the pre-clinical phase and 252 were at the clinical phase. These involved both male and female subjects, who were instructed separately as with all other courses in the curriculum. The names of the four participating universities have been replaced in this report with the letters A, B, C and D to protect their identities.

Table 4.1 Distribution of student groups for the curricular interventions

University	Pre Clinical				Clinical				
	LBC		PBL		LBC		PBL		
	Female	Male	Female	Male	Female	Male	Female	Male	Total
A	24	24	24	24	14	16	14	16	156
B	15	16	15	14	24	28	24	28	164
C	12	8	12	8	12	12	12	12	88
D	8	8	10	10	11	10	9	10	76
Total	59	56	61	56	61	66	59	66	484
Total	115		117		127		125		484
Total	232				252				484

Approval for the use of individuals participating in this study was secured from the Saudi Deans Council (SDC) of the medical colleges at the Ministry of Higher education in Saudi Arabia and the School of Education at Durham University (see Appendices E and F).

The study involved a variety of research methods designed to test the research hypotheses. As defined by Cohen et al. (2004), research methods are a range of approaches used as a basis for inference and interpretation, for explanation and prediction. The following discussion of the process of scientific inquiry in general will aid a later exposition of the particular process and details of the methods used for the current study.

4.2 Mixed methodology: qualitative and quantitative

Firstly, all research methods can be classified broadly into qualitative and quantitative strategies (Bryman, 2004). Quantitative research methods include the examination of hypotheses and research procedures; the control of contextual factors that might interfere with the interpretation of the results; an awareness of sample size to avoid over interpretation; and little personal interaction between researchers and participants, since most data is gathered using paper-and-pencil or similar non-interactive instruments.

Qualitative research methods, on the other hand, are often perceived to be based on an entirely different set of beliefs and aims to those of quantitative research methods. Many qualitative researchers do not see the world as stable, uniform and coherent (Gay & Airasian, 2003). Gay and Airasian argue that all meaning is situated in a particular perspective or context and, since different people and groups have different perspectives and contexts, there are many different meanings in the world. Sources of qualitative data are open-ended questions, interviews, observations, phone calls, personal and official documents, photographs, recordings, drawings, e-mail and informal conversations (Gay & Airasian, 2003; Bryman, 2004). The most commonly used qualitative methods are open-ended questions, interviews and observations. In this study, we have used the open-ended question method.

Depending on the type of research, a researcher may find one approach more appropriate than the other. Both approaches can, however, borrow from one another or be used together (Gay & Airasian, 2003; Bryman, 2004). For example, the administration of a questionnaire (quantitative) may be followed up by open-ended questions (qualitative), and this is what was used in this study, to obtain deeper explanations for the numerical data. Bryman (2004) refers to the use of one approach as 'mono-method' or 'mono-strategy' research, and the mixed quantitative/qualitative approach as 'multi-strategy' research.

4.3 Types of instruments

The issue of how best to ask questions should be a matter of concern to every researcher when constructing a research instrument (Bryman, 2004), since questions are always used in some form or other for the collection of data. A well-planned and carefully constructed research tool will both increase the response rate (Burns, 2000) and greatly facilitate the summarization and analysis of the data collected.

The current study has used surveys with open-ended questions in order to collect data. According to Bryman (2004), data in survey research is predominantly collected using questionnaires at a single point in time, with an underlying assumption that the respondent will be both willing and able to give truthful answers (Burns, 2000). According to Tuckman (1999), these research techniques enable researchers to measure what someone knows (knowledge or information), what someone likes and dislikes (values and preferences) and what someone thinks (attitudes and beliefs).

Three kinds of items are generally employed to construct questionnaires. These are closed items (e.g. yes/no questions), open-ended items (where the answer is neither guided nor limited by the question) and scale items (involving a set of verbal items requiring the respondent to indicate degrees of agreement or disagreement (Burns, 2000)).

The advantages and disadvantages of using each of the items employed in questionnaires are discussed below.

4.3.1 The advantages and disadvantages of using closed items

Closed items usually permit the respondent to choose from a set of fixed alternatives (Bryman, 2004). The most frequently used are the dichotomous items which offer two alternatives only, for instance yes / no or agree / disagree. The researcher ensures that the alternatives offered are exhaustive. The advantages of using closed items are:

1. They achieve greater uniformity of measurement and therefore greater reliability.
2. It is easy to process answers because respondents are forced to reply in a manner fitting the response categories.
3. They enhance the comparability of answers because they are easily coded.
4. They reduce the possibility of variability in the recording of answers in the structured interviewing.

Disadvantages of closed items include the following:

1. Respondents may feel frustrated if none of the alternatives are suitable.
2. There may be a variation among respondents in the interpretation of forced-choice answers.
3. It is difficult in practice to cater for all possible answers or to make the forced-choice answers exhaustive.

4.3.2 The advantages and disadvantages of using open-ended items

Open-ended items do not put any restriction on the respondents, who can reply however they wish when asked a question (Cohen et al, 2004), and thus form the essential ingredient of unstructured answers (Williams, 2003). The advantages of open-ended items are:

1. Respondents' answers can be probed for more depth.

2. Respondents are free to answer in their own terms.
3. They allow unusual responses to be derived.
4. They encourage cooperation and help to establish rapport.
5. They are useful in generating fixed-choice format answers.

Open-ended items do have some disadvantages, including the following:

1. They have to be coded, which is time-consuming.
2. They are time-consuming for researchers to administer because respondents are likely to write for longer than is usually the case with comparable closed questions.
3. They require a greater effort from respondents.
4. The respondent may choose to avoid the question or go off at a tangent.

4.3.3 The advantages and disadvantages of using scale items

The most common scale items are attitude scales (Fraenkel & Wallen, 2006). Fraenkel & Wallen emphasize that the basic idea behind all attitude scales is that it is possible to measure attitudes by asking individuals to respond to a series of statements of preference. According to Gay and Airasian (2003), attitude scales determine what an individual believes, perceives, or feels about him/herself, others, activities, institutions or situations. The five basic types of attitude scale described by Gay and Airasian are the Likert scales, semantic differential scales, rating scales and the Thurstone scales, of which the Likert scale is most widely used (Fraenkel & Wallen, 2006). Most researchers look at measuring attitudes by creating a scale from a series of items. According to Gay & Airasian, 2003; Cohen et al, 2004, the advantages of scale items are as follows:

1. They provide more discrimination than dichotomous questions, rendering data more sensitive and responsive to participants. This is particularly useful for tapping attitudes, perceptions and opinions of respondents.
2. They combine the opportunity for a flexible response with the ability to determine frequencies, correlations and other forms of quantitative analysis.

3. They allow the researcher the freedom to fuse measurement with opinion, quality and quantity.
4. The empirical data obtained regarding subject responses is easy to analyse at a low level, although the possibilities of complex analyses open up.

The disadvantages of scale items include (Gay & Airasian, 2003; Cohen et al, 2004):

1. The researcher can never be sure that the respondents are truthful in their expressions because scales are self-report instruments, although some instruments include deliberate checks for truthfulness. Every effort should therefore be made to increase honesty of responses by giving appropriate directions to the respondents before completing the items.
2. Scores can be meaningful only to the degree that the respondents are able to respond and select choices that truly characterize them.
3. One cannot infer that the intensity of feeling in the Likert scale between "strongly agree" and "agree" somehow matches the intensity of feeling between "strongly disagree" and "disagree" because these are illegitimate inferences.
4. The existence of a response set is common, i.e. there is a tendency among participants to respond continually in a certain way, for example to always select "agree" or to choose those items that the respondent believes are socially acceptable to the researcher. Several techniques have been developed to help avoid this problem.

4.4 Constructing the questionnaire

The main purpose of the questionnaire used in this study is to yield reliable evidence related to its objectives. It is a scientific tool for the collection and measurement of particular kinds of data, and not just a list of questions to be answered. Questions need to be carefully constructed and relevant to the hypotheses of the study.

According to Oppenheim (1992: 100),

> "The questionnaire has a job to do: its function is measurement. But what is it to measure? The answers to this question should be contained in the questionnaire specification. Many weeks of planning, reading, design and exploratory pilot work will be needed before any sort of specification for a questionnaire can be determined, for the specification must follow directly from the operational statement of the issues to be investigated and from the research design that has been adopted."

Slavin (1984), McKernan (1991) and Gay and Airasian (2000) suggest that, in order to build a good questionnaire for any research in educational and social fields, there are general guidelines to be followed. Questions need to be easy to understand rather than long and complex; they should be significant or specific to the study; questions which have two parts should be separated; and, in multiple choice questions, all possibilities should be mentioned.

Cohen and Manion (1989) discuss four types of questionnaire: the mailed questionnaire, the self-administered questionnaire, the group-administered questionnaire and the electronic questionnaire, which now takes place via. the Internet in various fields of inquiry.

In this study, the researcher has used a self-administered questionnaire, in order to help ensure that all questions were answered and to assist the respondents in understanding the questions that were not clear or comprehensible to them. The questionnaire consisted of closed questions, since these are considered easier and quicker to answer, and because quantification is straightforward, facilitating data analysis.

Gay and Airasian (2000), Oppenheim (1992) and Cohen et al. (2001) state that the most important advantages of the questionnaire are as follows:

1. It is not difficult to allocate and complete.
2. It is possible to distribute to many different samples simultaneously.
3. Response are easy to count and the figures easy to enter into a table.
4. Reply to the questionnaire through writing gives the respondents a means of expression themselves anonymously.

5. Questionnaires are able to reach respondents in remote or distant areas.

On the other hand, McKernan (1991) and Gay and Airasian (2000) highlight the disadvantages of the questionnaire, such as:

1. Sometimes questionnaire data need more time for analysis, especially if they include open-ended questions.
2. In some instances, respondents do not complete the questionnaire or provide dishonest answers.
3. Entering the responses into a computer program for analysis may cost a lot of money.

Prior to the main fieldwork application and as a first step in the design of the methodology instrument (questionnaire) applied in this study, the researcher had preliminary contact with people belonging to the different universities.

In order to develop the questionnaire for this study, it was necessary to read previous studies to see if a suitable tool already existed which had previously been tested in a similar context to the current study. Unfortunately, no suitable tool for the sample was found and, as a result, the researcher needed to design appropriate questions for this study. In order to construct a suitable questionnaire (see Appendix A), the researcher conducted a review of other literature related to questionnaire design, such as Krakov et al. (1990), Mitchell (1992) and Wilkerson et al. (1991).

The questions were designed to invite responses along a seven-point scale, where 1 represented the least and 7 the most true/representative/etc., in order to give respondents more freedom of choice. This is a commonly-used method in educational and social fields (Robson, 1996).

4.5 Research hypotheses

In order to evaluate the hypotheses set out in Chapter 2.7, the current study used a mixed methodology (quantitative and qualitative) employing Likert-type scales and open-ended questions, collecting data on students' cognitive, behavioural and experimental responses to the PBL and LBC curricula. The data were collected in a variety of ways, including a demographic questionnaire, an attitudinal survey, a cognitive behaviour survey and a course evaluation survey. These methods of data collection are discussed in detail below and in Appendix A.

4.6 Methods of data collection

4.6.1 Demographic Questionnaire (DQ)

Prior to the curricular intervention, students completed a demographic questionnaire which secured information about such factors as their age, year of study, interest in human genetics, pertinent work experience, previous coursework in human genetics, and prior exposure to and perception of PBL methods and case-study approaches.

4.6.2 Attitudinal Survey (AS)

This survey collected information about subjects' attitudes to learning and to patient problems. A self-report Likert-type survey was used, modelled after one developed by Krakov, Preston and Rubin (1990). It was administered both before and after the study, with a comparison of pre- and post-test scores in order to detect and analyse any differences between treatment groups. Random administration of pre-attitudinal surveys was utilized to reduce the potential for the testing itself to negatively affect the survey's internal validity. A self-report survey of the students' working knowledge of medicine was included in this survey.

4.6.3 Cognitive Behaviour Survey (CBS)

A cognitive behaviour survey was used to measure changes in learning behaviour over the course of this study. The CBS was patterned after a survey developed at Harvard Medical School to monitor learning strategies for students in the school's PBL track (Mitchell, 1992), where survey items were created by faculty and via student interviews about learning behaviour and strategies. Three levels of information were provided by the CBS: a) descriptive data about learning behaviour, learning experience and epistemological beliefs gathered by Likert scale, rank-order, and fill-in questions; b) measures of cognitive behaviour were based on the categorization of responses to memorization, conceptualization and reflection scales which indicated the extent to which students viewed learning in a positive or negative light.

The survey included several subscales:

- The *knowledge retention / reflection* sub-scale, divided into ten items and providing specific information on the use of rote learning techniques, beliefs about the role of memorization in learning, and the degree of reliance on memorization in reading comprehension. (Reflection includes integrating information from different disciplines, reviewing previously-studied materials for similarities and differences, and making conscious decisions about organising material and self-assessing understanding).
- The *knowledge requirement* sub-scale, which included six items assessing students' awareness of their genetics knowledge.
- The *problem-solving and critical thinking* sub-scale, including six further items constituted which assessed students' ability in reading, in remembering a large number of details, in formulating conceptual models and in constructing mental pictures to represent information.
- The *motivation* sub-scale, with ten items asking students to qualify in writing their motivation in association with the human genetics course.
- The *self-directed learning* scale, comprising eight further items that assessed how students learn by themselves, i.e. without direction from their tutors.
- Finally, the sub-scale relating to *level of preparation* included three items and assessed whether students study alone or with other students, and how regularly.

4.6.4 Course Evaluation Form (CEF)

The following measures were used in order to evaluate the course:

1. Semantic differential questions to judge tutorial content and format

2. Forced-choice items to indicate the relationship of learning outcomes to subjects' expectations
3. Numeric replies to describe time investment and extent of genetic study
4. Likert-type scales, identical to those in the tutor journal, to measure student-centred tutorial discussion
5. Open-ended questions to expand on genetic topical activity and to solicit questions, comments or suggestions from subjects
6. Forced-choice descriptors of objective fulfilment
7. Multiple choice format and open-ended questions to secure suggestions for future improvement in the curriculum.

To ascertain the likelihood and possible effects of contact between curriculum groups, subject awareness relating to the activities of other groups was assessed. These evaluations were completed anonymously. Forms were provided to students on the last day of the study unit and were completed in the classroom.

4.6.5 Genetics Unit Examination (GUE)

The genetics unit examination was used to test mastery of unit content. This examination was written by the Genetics Instructor at University B, and by the researcher. To ensure content validity, expert input was provided by lecturers and tutors in human genetics in the other Saudi universities participating (Universities A, C and D).

The examination comprised two parts: Part I had multiple choice, true or false and matching questions, worth 60 points in total; Part II included structured essay questions worth a total of 40 points, subdivided into the human biochemical disorder (20 points) and the human chromosomal disorder (20 points). The two parts were administered sequentially as part of a two-hour examination, and used identification numbers rather than names in order to anonymise the grading process. The course researcher graded Part I, and the tutor graded Part II.

As was noted in section 2.6.2, there are arguments which suggest that the traditional examination is inappropriate for the assessment of PBL education. But in the present context, students must take the examination and so, for pragmatic reasons, the exam results were included in the outcome measures.

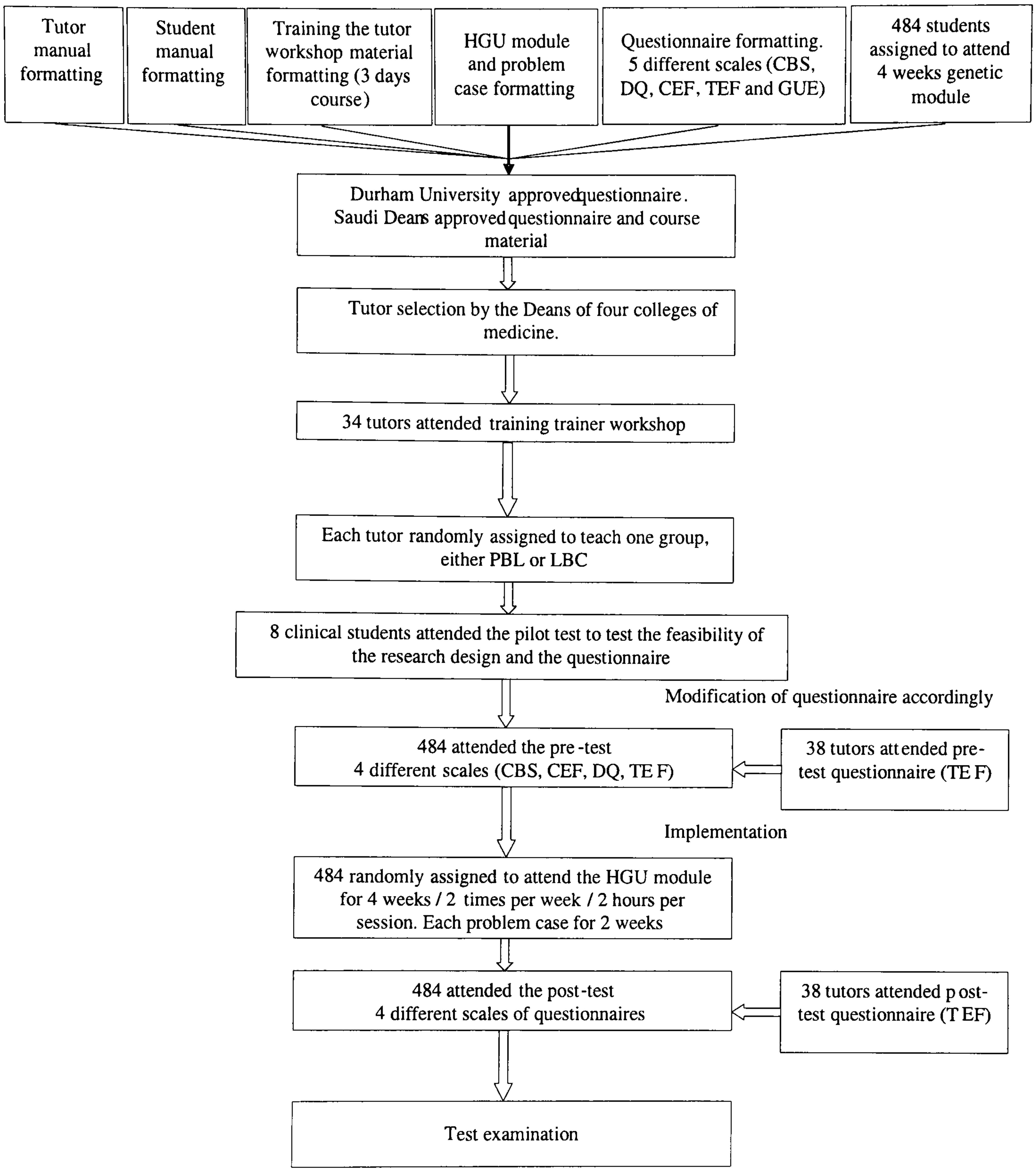
4.6.6 Tutor Evaluation Form (TEF)

In order to study PBL and LBC small-group processes, the tutor evaluation form was modified further by the researcher to benefit this study by using a Likert-type scale developed by Wilkerson, Hafler and Lui (1991). A sample is found in Appendix A.

This survey was used to measure the student discussion in which student participation, tutorial progress, the PBL process, student involvement and performance were accomplished. It also collected qualitative data regarding tutors' perceptions of the method of teaching.

Figure 4.1 shows the process within which these methods were used for the collection of data.

Figure 4.1 Methods of data collection



4.7 Description of the curricular intervention

4.7.1 The general outline of the human genetics unit

The aim of the human genetics unit is to help students understand the principles of the functional changes that occur in genetic diseases and to apply this knowledge to the interpretation of clinical problems. The participants (male, and female, pre-clinical and clinical students) receive instruction on the same topics in the same order. The objectives of the unit are as follows:

1. To define and recognize changes of human structure and function in genetics disease processes
2. To explain the basis for laboratory procedures used in the investigation of diseases
3. To use the common terms employed in medical contexts correctly and appropriately
4. To attain sufficient skills in medical science to be able to apply this knowledge to explain and understand clinical signs and symptoms
5. To communicate in a written or oral examination clearly and intelligibly using current medical nomenclature.

4.7.2 Description of the PBL problem cases used

Problems and case studies utilized for this research were specifically formulated for this study by the investigator, in consultation with medical experts in the United Kingdom and Saudi Arabia, and were evaluated by a PBL expert familiar with Barrow's taxonomy to ensure that they were representative of CPBL. The principles of problem creation, as discussed by Barrows and Tamblyn (1980) and Curry (1991a), guided the development process. According to Amin and Khoo's (2003: 123) summary, these principles recommend that a PBL "problem" should have the following characteristics:

1. "It should match the level of knowledge previously acquired so that the reactivation of existing knowledge is facilitated
2. It should be formulated concretely and demonstrate a clear linkage to students' future professions

3. It should initiate learning over the widest possible span of the subject area and direct students to address one or more faculty-directed learning objectives
4. It should allow students to apply newly-learned facts to a clinical condition."

For the current investigation, four problems were developed for each of the PBL and the LBC groups, based on two disorders each studied at both pre-clinical and clinical levels, in order that students participate at their normal level of study. Of the problems for both groups, one related to a human biochemical disorder (HBD), whilst the other related to a human chromosomal disorder (HCD).

In the LBC group, students received primarily didactic instruction on each type of disorder, with lectures followed by the study of a case relating to the lecture material. (These case studies were evaluated prior to the investigation, to ensure that they did not directly foster any PBL educational objectives). The four problems utilized in the PBL tutorial, however, were based on actual patients, with slight modifications to facilitate fulfilment of the course objectives and the students' level of study.

The problems set will now be discussed in full.

4.7.2.1 Human Biochemical Disorder (HBD) problem case

The HBD problem for the two levels of study was obtained with permission from the medical records of King Fahad Hospital at King Faisal University, Saudi Arabia. The development of the problem was guided by the elaboration of the unit objectives as a part of the general course objective, to specify the genetics knowledge required according to students' level in the current curriculum. The unit objectives were as follows:

1. To describe the DNA composition of chromosomes in terms of structure, replication process and arrangement
2. To define the general structure and function of amino acids and the role of RNA components in protein synthesis
3. To discuss the principles and methods of laboratory molecular genetics and its utilization in medicine

4. To explain the techniques for the analysis of proteins and amino acids and their main differences
5. To describe the application of genetic engineering in medicine
6. To construct a pedigree chart for a family
7. To discuss the types of Mendelian inheritance in humans.

The problem was introduced towards the end of the first and during the second tutorial session, and involved a 14-month-old female who had been brought to the Paediatric Clinic. She had been coughing, was irritable and feverish, and, whilst she had started to walk about five weeks previously, had not been able to put weight on her left leg for two days. The child was admitted with sickle-cell anaemia in the knowledge of a family history of the disease (see Appendix B).

The other problem set was a human chromosomal disorder (HCD):

4.7.2.2 Human Chromosomal Disorder (HCD) problem case

The HCD problems also were obtained with permission from the medical records of King Fahad at King Faisal University, Saudi Arabia. Their development was again guided by the elaboration of the unit's objective to specify the knowledge that was required and students' level of the current curriculum. The unit objectives were as follows:

1. To describe mitosis and meiosis as mechanisms of cell growth and reproduction
2. To provide details of the human chromosome and the karyotype in human genetics
3. To explain the role of molecular cytogenetics in DNA diagnostics
4. To explain the mechanism of non-disjunction in gametes and its effect in humans
5. To discuss the autosomal trisomic condition and its risk factors
6. To describe sex chromosome abnormalities and their effect on the phenotype
7. To list the characteristic patterns of Mendelian X-linked inheritance
8. To explain mutation in the human genome.

The problem set involved a patient who had been referred to the gynaecological and obstetrics department from a local primary health care centre. The patient was a 15 year old female, short in stature and obese, who had a primary amenorrhoea (her menstrual period had not yet begun). The problem was slightly modified, to represent a typical Turner Syndrome patient by introducing a specific clinical and laboratory description of this type of syndrome (see Appendix B).

The research provided direct information to present the problem with the same kind of information normally available to the clinician (Barrows and Tamblyn, 1980). This problem was introduced in the first and second tutorial sessions.

4.8 PBL tutorial process

4.8.1 Closed-Loop Problem-Based Learning (CPBL) tutorial sessions

In the CPBL sessions, tutorials for approximately seven to eight students involved studying a problem with guidance from a staff tutor. Problem study began in the first session with the presentation of the problem-brief, a general statement of the topic. Students were given 3-4 minutes to generate a list of pertinent issues they wished to study, which they were allowed to amend and refer to at any point. Next, each student received a copy of the problem vignette (case), and one student acted as a discussion leader. A volunteer student served as a minutes secretary to capture ideas, hypotheses and concepts on a blackboard.

Students also assigned themselves learning issues, generated during discussion. Students were permitted to self-select references from a binder of problem-specific articles which was placed on reserve in the college library. Resource lists accompanied each problem.

Problem study continued during the second class, with students reporting and integrating the findings from their self-directed learning experiences. Generation of ideas, hypotheses, concepts and learning issues continued from the previously identified problem brief, and an additional piece of information – a problem "trigger"

– was introduced in order to continue the development of learning issues. One of the two problems used with the pre-clinical subjects was also introduced as a trigger at the end of the first session (see Appendix D).

In the third session, students were required to submit a collective clinical plan, after which they received the clinical application actually developed by physicians for the patient described in the case material. Students compared their reasoning processes and strategies to those used by the professionals, promoting reflective thinking (see Appendix D).

The room set aside for the PBL tutorial was chosen to encourage and support the learning process, with moveable chairs and tables and an informal atmosphere. The PBL group was assigned the same room for all class periods of both study units, whilst the LBC group moved between lecture halls. This is because the PBL course needed certain room-specific equipment, whereas the LBC lectures could take place in any lecture hall or classroom.

4.8.2 LBC tutorial sessions

Lectures were guided by the unit's objectives, and were written and presented by the faculty members who would normally teach the students.

At the end of each lecture, students were provided with a list of targeted questions designed to demonstrate the relevance of the lecture material and encourage a review of lecture notes. This was then taken up in the second class, with students working in pairs to answer these questions. The final session consisted of a large group discussion focusing on the students' answers to the targeted questions. The completed questionnaires were submitted to the instructor at the end of the final session.

Two lecture rooms with immovable desks not conducive to small-group discussion were used for the LBC group at each college.

4.9 Description of the tutorial group meetings

4.9.1 The first tutorial group meeting

At the beginning of the tutorial, students introduced themselves to one another and gave details of their background. The ground rules for the groups were discussed to reinforce the need to participate freely and fully without fear of criticism from other participants. Two students were then asked to volunteer, one as a discussion leader, to maintain the educational systematic procedure and to monitor the group process; the other as a minutes secretary to take down what was said by the group and thus avoid the loss of information. A blackboard and a note sheet were used for this purpose.

The problem brief was handed out and the students were given enough time to read it, to take notes and to decide on their learning objectives. The problem task was also handed over to the students. They read it by themselves and then applied the seven step approach named "seven jumps", explained below (Sanford, 2007: online; Maastricht, 2007: online; Adelaide, 2007: online). The first 3 steps occur during the first tutorial group meeting:

The Seven Step Approach ("Seven Jumps")

Step 1: To clarify and define the terms and concepts which are not clear in the context of the problem. Students may bring in medical dictionaries and other resources to use in class if they wish.

Step 2: To explain the problems arising when students explore the problem in context. They may also divide the problem into sub-problems which can be discussed in a specific order. In the current investigation, this step was implemented by using the brain-storming process to motivate further discussion of the problem.

Step 3: To analyse the problem that the students discussed, and to think about the various possibilities which underlie the process and also the mechanisms within the problem. Students continue this process, scanning for new information, and creating new hypotheses. This step activates prior knowledge and acts as a basis for further discussion.

The tutor plays the role of evaluating and managing the problem, according to the knowledge and skills previously acquired by students.

4.9.2 The second tutorial group meeting

Step 4: To sort out the best hypothesis. By critically analysing the hypotheses, the ideas that have been previously generated can be prioritized and the different explanations evaluated. This step activates existing knowledge.

Step 5: To generate learning objectives. The hypotheses that the students identified during the analysis of the problem should enable a better understanding during this step. These learning objectives are established as a learning activity by the group and assigned for independent study. This step directs the learning process for students.

The minutes secretary recorded the learning objectives on the Student Learning Objective Sheet (SLOS) which the Tutor handed to the researcher at the end of the session.

4.9.3 The third tutorial group meeting

Step 6: Self-directed learning during which individual students implement the learning objectives identified in step 5 and look through different learning resources or consult the faculty member. This step helps the students to gather relevant information and to understand the subject matter. Students may decide as individuals or to meet informally to work together.

At the end of the third meeting, students completed the demographic questionnaire.

4.9.4 The fourth tutorial group meeting

Step 7: To report the self-directed study activities and progress on learning objectives. Students provided the group with this information orally, referring to hand-outs. Tutors managed each student's presentation to ensure that their turn was efficiently utilized. This step involved the identification and discussion of any uncertainties in the subject matter studied. This activity also broadened individual students' knowledge through exchange of information among group members.

Students felt that they spent more time on the embedded issues than on solving the problem, and suggested a clinical treatment plan for the problem. This information was recorded by the minutes secretary on a student suggestions clinical plan (SSCP), and handed it to the tutor. At the end of the session, the tutor provided students with the clinical application section of the treatment plan used in the hospital, and then encouraged them to compare their plans and proceed with the discussion.

For the post-test, CBS, AS, CEF and DQ surveys forms were completed at the end of the last day of the study. The genetic unit examination and the tutor evaluation form were completed the day after the end of the study.

4.10 Preparation of the students for the study

At the beginning of the semester, both male and female students on the selected courses were informed by their tutor(s) whether the PBL or the LBC approach would be used to teach them the genetics unit of their course, and were told that the genetics unit examination (GUE) results would be counted as 25% of the total course grade, as agreed by the Committee of Deans. Students were informed that assignation to PBL/LBC groups was random, and that further details would be provided as necessary over the course of the study.

Before the genetics classes began, students were introduced to the research tutor, who briefly discussed the study to allay any fears about the impact of study participation on grades or on the amount of knowledge they would acquire, and to eliminate any misconceptions the students might have of PBL. Emphasis was placed on the importance of quality in the instruction of human genetics.

4.11 Preparation of the tutors for the study

Qualified tutors interested in the research were identified by the Deans of the colleges of medicine as potential tutors for the two groups in the study. Eighteen male and sixteen female tutors were selected and trained by the investigator, each of whom was randomly assigned to a specific tutorial group, either PBL or LBC using a computerised random-number generator. Qualifications of the tutors included experience in providing instruction in human genetics components at the pre-clinical level and clinical level, and interest in participating in an evaluation of teaching methodology.

Training for tutors was provided in sessions held prior to the study. (The training agenda for tutors can be found in Appendix C). Tutors were provided with a copy of Barrows's 'The tutorial process' (1988) as well as selections from Curry's 'The facilitators' guide to small-group process' (1991b), which provided them with a common source of knowledge for their participation in the study. Specific instructions for utilizing the PBL process in this study were also provided (see Appendix C). Other resources included materials developed at McMaster University and Maastricht University to train tutors, which were used, with permission, in order to facilitate the tutor-training process (McDermott & Anderson, 1991). In this way the methods of instruction for tutorial sessions was standardized for all tutors.

One simulated tutorial session was held following training and before the research subjects began their PBL study, in which volunteer clinical students were used as the students. Problems and cases were used and the recording forms for the evaluation were introduced to tutors as a part of their training process.

Each tutor was provided with instructions clearly spelling out the daily plan of study for this research, as well as specific instructions for the collection and distribution of materials and problem triggers. These instructions can be found in the tutor training development material in Appendix C.

4.12 The pilot test

Before beginning the study itself, a pilot test was carried out. A group of sixteen student volunteers were divided into two groups, one to study PBL and the other to study LBC. These volunteers were clinical students who enrolled at University B in 2006.

The aims of the pilot test were to:

1. Test the feasibility of the research design
2. Test the technical feasibility of implantation and conduct further procedural refinement.
3. Test the questioner's items, module material and course process.

The PBL intervention was performed in line with the guidelines below, devised by Bayard, Nitzke and Nuhlicek (1992):

1. The problem and case study is to be concluded within one week for each problem.
2. Sessions must be separated by at least one day, but no more than four.
3. The most functional size of a tutorial is six to eight students.
4. Session lengths between 1½ hours to 2½ hours are the most productive and time should be allowed for evaluation and testing.
5. Excessive demands of other courses or projects should be minimized or avoided.
6. Problem and case selection should reflect curricular inadequacies or special needs defined by the clinical students.

For this study, a specially designed module on a human multifactorial disorder (HMD) was made available.

The objectives of the module were:

1. To explain Mendelian inheritance and the difference between autosomal recessive, autosomal dominant, co-dominant and X-linked chromosomes.
2. To list the common multifactorial disorders in genetics.
3. To discuss environmental agents common in causing multifactorial disorders.

4. To construct a pedigree pattern for a family with a particular multifactorial disorder.
5. To explain the role of cytogenetics in DNA diagnosis in medicine.

4.12.1 Reliability of the instruments

Reliability is the level of internal consistency or stability of the measuring instrument over time (Borg & Gall, 1989). To test the reliability of the questionnaires, the split-half method was used to establish the coefficient of internal consistency. This method involves splitting the statements of a test into two halves, in this case odd and even-numbered items (Roscoe, 1969). The odd numbered items and even numbered items of each questionnaire were placed into sub-tests after splitting. Then, the scores of the two sub-sets for each questionnaire and in each of the pilot studies were computed for each individual and correlated using the Pearson Products Moment Correlation Coefficient Formulae indicated below.

$R=[\sum xy - (\sum x)(\sum y) / N] / \sqrt{} [\sum x^2 - (\sum x)^2 / N] [\sum y^2 - (\sum y)^2 / N]$, where

$\sum xy$ = sum of the cross product of the values for each variable.

$(\sum x)(\sum y)$ = Product of the sum of x and sum of y.

N = Number of pairs of scores.

R = Correlation coefficient

However, the correlation coefficient obtained (r) represents reliability of only half of the test. In order to obtain reliability of the whole test (instrument), the Spearman-Brown Prophecy Formula indicated below was applied:

$r_e = 2r / (1+r)$, where

r_e = the reliability of the whole test, and r = the reliability co-efficient resulting from correlating the scores of the odd statements with the scores of the even statements.

The measurement instrument is considered to have a high degree of reliability when it is consistent and accurate. Devellis (1991) suggests that the acceptable degree of reliability for questionnaire tools is as follows: below 0.60 is unacceptable; between

0.60 and 0.65 undesirable; between 0.70 and 0.80 acceptable; between 0.80 and 0.90 highly acceptable; and 0.90 strongly reliable.

In order to achieve a high level of reliability in the questionnaire, a pilot study was carried out, as previously explained. Reliability analysis following the pilot test indicates that the subscales that were derived from all the questionnaires were reliable with a minimum Cronbach alpha of 0.71 for *learning experience* and a maximum of 0.97 for *level of preparation* (see table 4.2). In addition, the pilot study resulted in some changes to the questionnaire in terms of clarifying some statements and rearranging the order of the questions.

Table 4.2 Cronbach Alphas for sub-scales

Questionnaires	Subscales	Questions	Alpha
Cognitive Behaviour Survey (CBS)	Fulfil knowledge requirement	CBS Q54-59	0.8
	Problem-solving and critical thinking skills	CBS Q11-16	0.7
	Knowledge retention (reflection)	CBS Q1-10	0.7
	Motivation	CBS Q25-34	0.9
	Self-directed skills	CBS Q17-24	0.8
	Level of preparation	CBS Q35-37	0.9
Attitude Survey (AS)	Learning about medicine	AS	0.7
	Working with patients	AS	0.7
	Career focusing on medicine	AS	0.9
	Problems associated with medicine	AS	0.8
Demographic Survey (DQ)	Learning experience	CBS Q46-53, DQ Q4-7	0.7
Tutor Journal Form (TEF)	Resources of information	CBS Q38-45, TEF Q15-28	0.7
	Tutors' perception of learning method	TEF Q1-14,	0.8

Table 4.2 shows that the questions within the questionnaire were divided into groups, each group covering one aspect of the research. The 'knowledge retention (reflection)' section, for example, includes CBS questions 1 to 10.

4.12.2 Validity of the instruments

Validity is a very important factor in successful research. According to Messick (1989:13), the definition of validity is

> "an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and actions based on test scores or other modes of assessment."

The validity of the research methods divides into four types as follows:

a) Slavin's (1984: 82) construct validity, defined as

   "Correlation between some scores on a scale or scores on another scale or measure of established validity given at about the same time."

b) The construct validity defined by Gall et al. (1996:249) as

   "the extent to which a particular test can be shown to assess the construct that it purports to measure."

c) Predictive validity, which Gay and Airasian (2000: 165) define as

   "the degree to which a test can predict how well an individual will do in a future situation."

d) Content validity, which Gall et al. (1996: 249) define as

   "the degree to which the scores yielded by a test adequately represent the content, or conceptual domain, that these scores purport to measure."

In the current study, the researcher depends on content validity as a way of testing the validity of the questionnaire and of other instruments used in the study. Content validity consists of several measures: first of all, the study tools must be carefully defined. Experts who work in the same field and in statistical analysis should then examine these instruments, and finally it must be ensured that the research tools used are appropriate to the concepts that they are to measure (Gay and Airasian, 2000).

In the current study, the researcher consulted a panel of experts who could provide useful advice; this panel included Professor Comfort Osonnaya, from Queen Mary University of London, and Simon Kometa, from the Computer Centre at Newcastle University, UK. A draft questionnaire and interview questions were distributed to these faculty experts before embarking on the pilot study; following their suggestions the questionnaire was reconstructed, with new questions added and existing questions modified. The new questionnaire was then tested in the pilot study, following which it was modified further. This procedure completed the treatment of the instrument to be used in this study.

Phase one of the pilot test indicated that the instruments needed improvement. Modification occurred accordingly, as follows:

1. Questionnaires modified to improve clarity of some items and to remove repetition in others.
2. Questionnaires modified to omit unnecessary items not covered by the study hypothesis.
3. Module material and case studies were further edited.
4. Refinements were performed on the process of module implementation.
5. Questionnaire scale items were reduced in number and complexity.

Phase two of the pilot study revealed that the question that was crucial in testing the null hypothesis on marital status in each questionnaire was missing. This was modified before the study occurred.

After all of this, the instrument was judged to be adequate for the study.

4.12.2.1 Threats of validity

The results of the first phase of the pilot study indicated the need for clarity in questionnaire items, in order that students understand the question being asked. Questions were consequently rephrased. Some items were found to be similar or to overlap in meaning; this was addressed through the appropriate removal or modification of affected items. Changes in the questionnaire following the pilot study greatly improved the instrument, and no further changes were made for the main study.

As previously stated, PBL/LBC group assignation was random and anonymous, through the use of computer-generated numbers representing each student. Students were not able to choose their group, and tutors had no role in placing students in certain groups. The following measures further ensured unbiased results:

- Students were encouraged not to talk to students of other groups about their learning experience.
- The 34 tutors assigned to participate in this study were trained as explained in section 4.11. They were distributed randomly to each method, whilst kept within their usual university.
- Tutors were given guidelines and informed of the rules and regulations of the study; they also received express instruction not to depart from the module contents or the activity schedule, as summarised in Appendix C. The tutors were especially encouraged to follow the tutorial process described by Barrows (1988).

4.12.2.2 Fidelity of implementation

It is clearly unavoidable that the tutors participating differ in knowledge, background and area of expertise. Therefore all tutors were trained equally with regards PBL, in order that they shared equal knowledge of the teaching method. However, one expectation of the study was that, in spite of this training, a lack of experience with PBL would mean that tutors would on occasion deal with issues wrongly (i.e. not in accordance with the PBL process). Thus the implementation of PBL was not able to be evaluated in its pure form, due to a lack of fidelity measures.

4.13 Data analysis techniques

Methods of results analysis differed according to whether results were qualitative or quantitative. Firstly, qualitative data included the essay-type written response required by certain questions. This was analysed using Nvivo (2006), a software package designed for qualitative researchers working with non-numerical or unstructured data. Nvivo allowed data from the open-ended questions to be classified, sorted and arranged, and also permitted the examination of complex relationships in the data, combining subtle analysis with linking, shaping, searching and modelling.

For the quantitative data analysis, several analytical procedures within Statistical Package for Social Sciences (SPSS) version 14 (2005) were employed. In order to ready quantitative data for analysis, it was first entered into Excel. The data was then checked and edited for transcription errors before being imported into SPSS for analysis. The SPSS procedures used included:

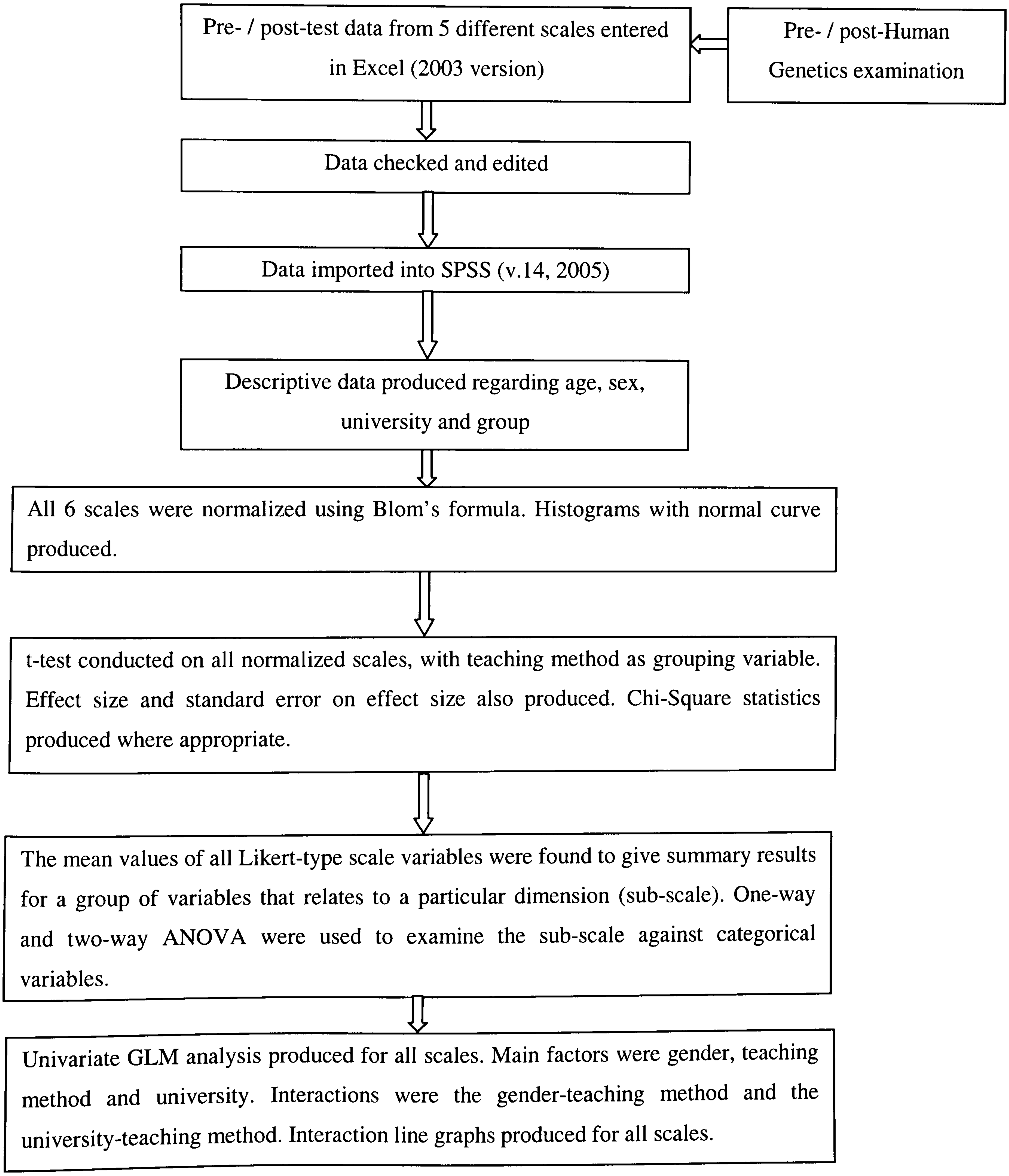
- **Descriptive statistics** were collected of the subjects who participated in this research.
- Where appropriate, **chi-squared statistics** measured the association between categorical variables.
- **Blom's Data Normalization Procedure** was used to normalize data from the scales that were formed. This was necessary because most statistical procedures assume that the data is normally distributed.
- **Independent Samples t-test Procedure**. This was used to establish any significant difference between the treatment and control groups, and was applied to both pre-clinical and clinical students.
- The **One-Way ANOVA and Two-Way ANOVA** methods were used to examine the main effects and interaction effects for outcomes measured on a continuous scale against categorical variables. The main factors were gender, teaching method, and university, whilst interactions examined included the gender-teaching method and the university-teaching method, i.e. a study of the relationships between gender and teaching method and between university and teaching method.
- The **Univariate General Linear Model.** Seven students swapped groups during the course of the research. To minimize the confounding impact of this on the research findings, univariate GLM was used to control for prior measures.

The Excel package and SPSS computer programs that were utilized for the pre-clinical data analyses were also used for the clinical subjects' data. Pre- and post-test responses from clinical tutorials, curricular problems and professional preparation levels were compared by means of a one-way ANOVA and a two-tailed t-test. For all tests, a p level of less than 0.05 was considered to be significant.

Data on tutors was also collected, in seeking opinions from both PBL and LBC group tutors after each session. In each case, the average response of three sessions was used. In addition, learning issues were analysed. Here, a method described by Dolmans, Gijselaers, Schmidt and Van Der Meers (1993) was used, wherein learning issues are related to problem objectives. The researcher scored the matching exercise, contributing to its construct validation.

Figure 4.2 gives a detailed summary of the data analysis techniques used.

Figure 4.2 Data analysis techniques



4.14 Summary

This chapter has described the methodology of this research study, which was conducted using a descriptive case study methodology with an embedded experimental design. The case methodology had supported the generation of descriptive and evaluative data on the use of PBL to provide genetics instruction to both pre-clinical and clinical subjects. Participants came from four colleges of medicine in Saudi Arabia.

The research involved a mixed methodology approach, using both qualitative and quantitative research methods. This has been discussed along with the advantages, disadvantages, strengths and limitations of the various data collection. The preparation of the students and tutors for the curricular intervention in this study has also been discussed, including detailed descriptions of the tutorial process and the case studies and problems used.

The research design, including the results of and modifications following the pilot test have also been presented within this chapter, with an exposition of the data collection and analysis techniques used by the study.

Chapters Five and Six will present the results and data analysis, both quantitative and qualitative, for pre-clinical and then clinical students, followed by a summary in Chapter Seven.

Section IV: Results and Data Analysis

Chapter Five

Results and Data Analysis I: Quantitative and Qualitative Data for Pre-Clinical Students

Chapter Five
Results and Data Analysis I: Quantitative and Qualitative Data for Pre-Clinical Students

5.1 Introduction

This chapter presents the results and data analysis of pre-clinical students, assuming random assignment. The quantitative results and data analysis are presented first, followed by the qualitative results and data analysis.

5.2 Quantitative Data

5.2.1 Distribution by treatment group

A total of 232 preclinical students took part in this research, of which 115 (50%) were placed in the LBC group and 117 (50%) in the PBL group. Placement within groups was assigned randomly.

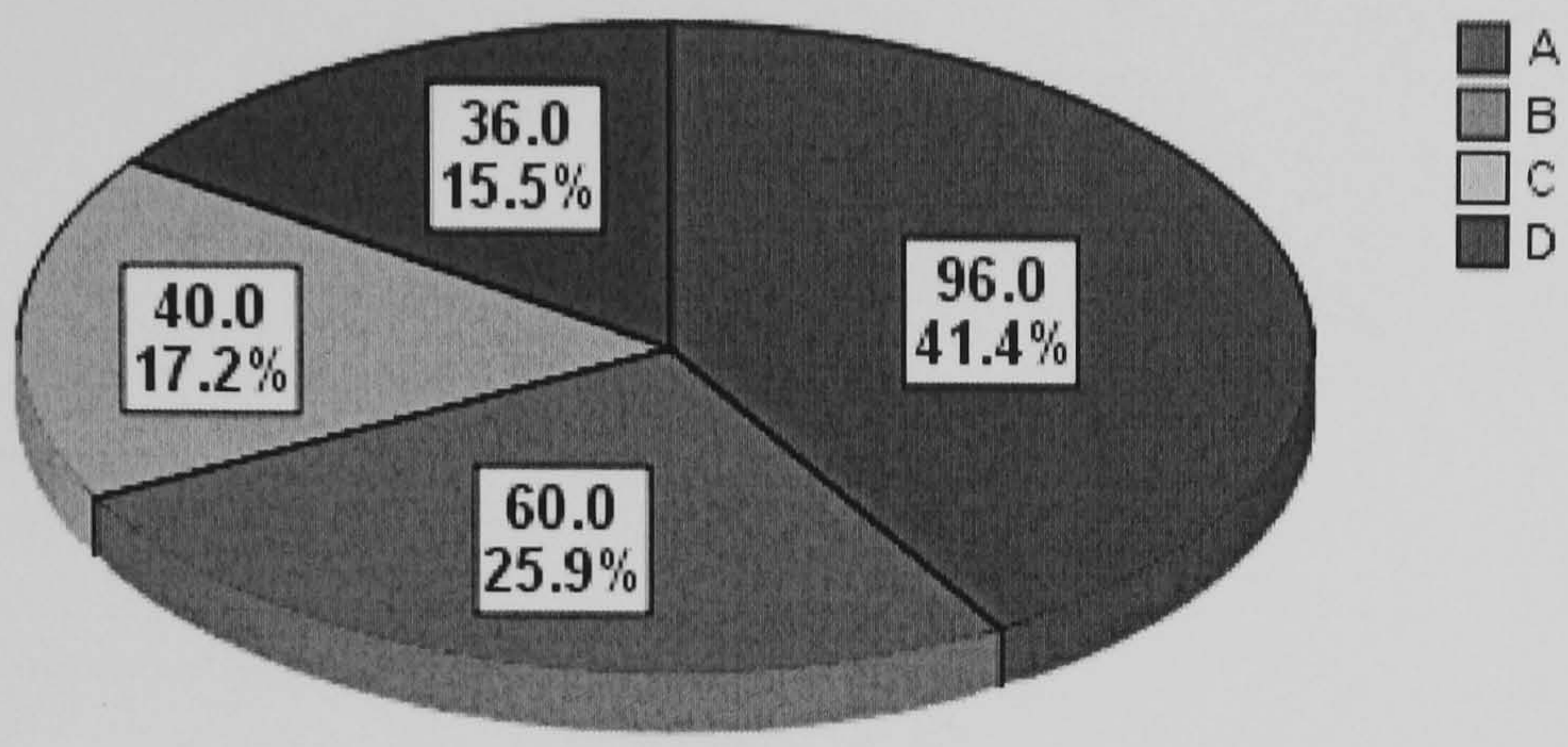
5.2.2 Distribution by gender

In terms of gender composition, 112 (48.3%) of the 232 pre-clinical students were male and 120 (51.7%) were female.

5.2.3 Distribution by university

In terms of distribution across the four universities, 96 (41.4%) of the 232 pre-clinical students were from University A, 60 (25.9%) were from University B, 40 (17.2%) were from University C and 36 (15.5%) were from University D (see figure 5.1).

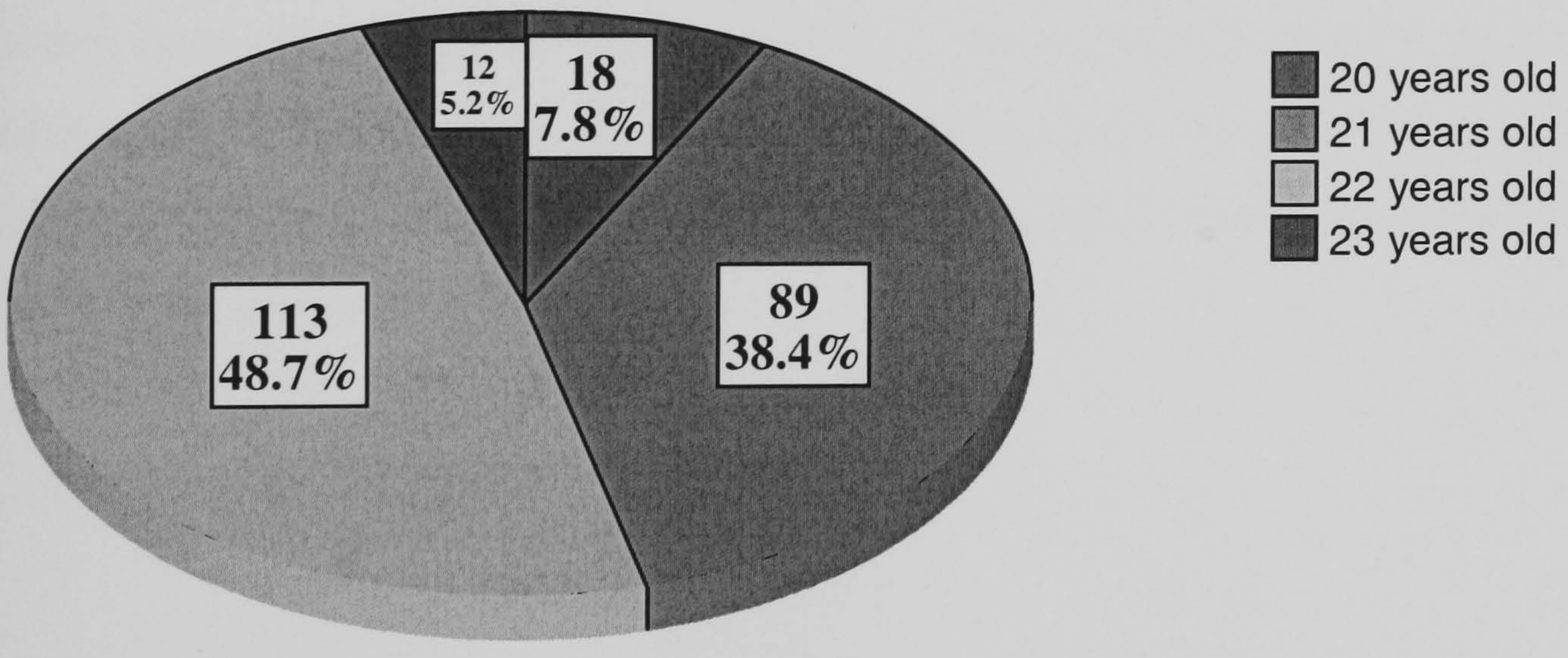
Figure 5.1 Composition by university: number and percentage of pre-clinical students



5.2.4 Distribution by age

The ages of the participating pre-clinical students ranged from 20 to 23 years old with a mean age of 21.5 years (see figure 5.2). The majority (just over 87%) of pre-clinical students were between the ages of 21 and 22 years.

Figure 5.2 Age distribution: number and percentage of pre-clinical students



The composition of treatment groups by stratification factors for pre-clinical students is shown in table 5.1.

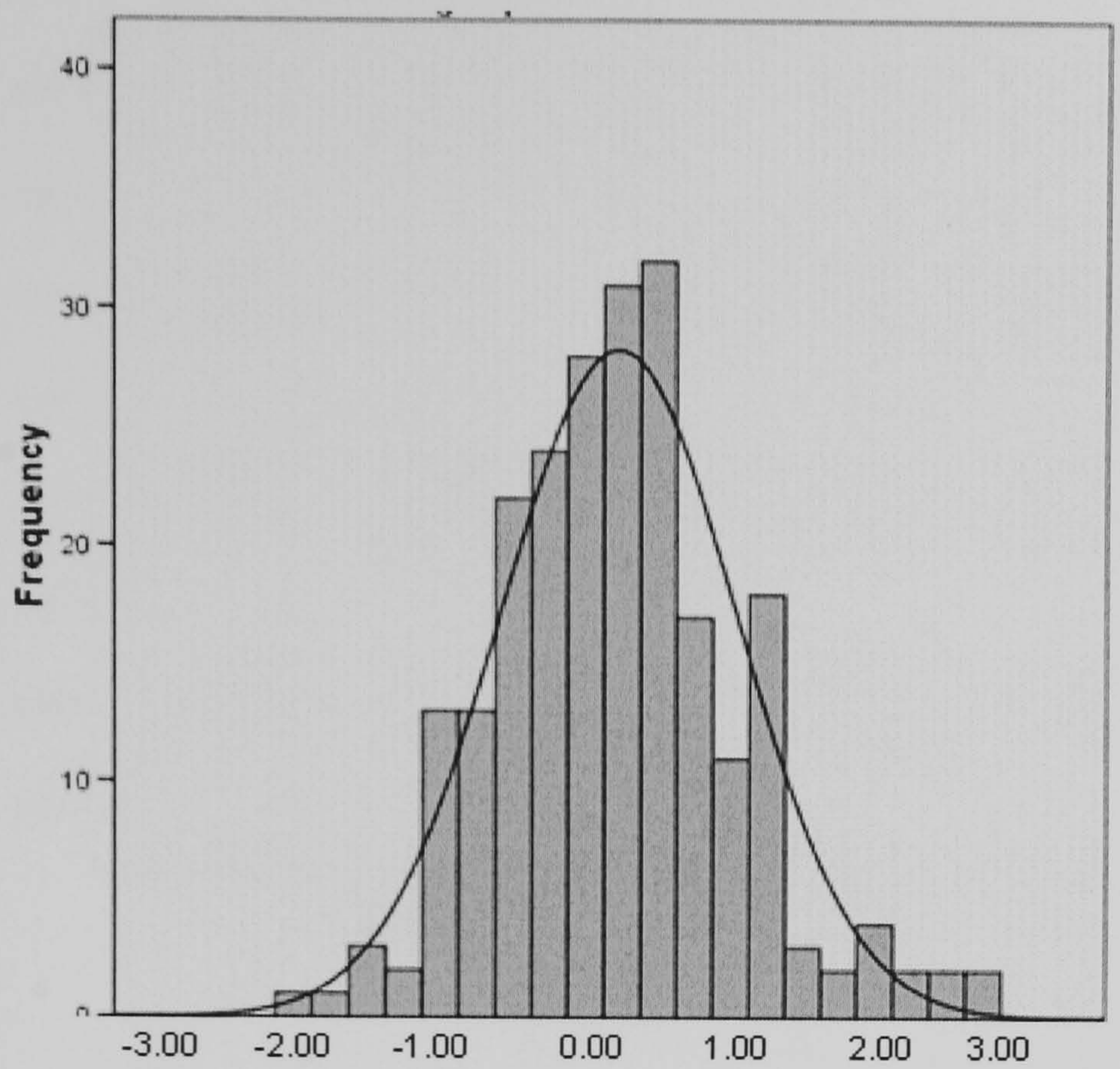
Table 5.1 Treatment group composition by stratification factors for pre-clinical students

University	LBC		PBL		Total
	Gender		Gender		
	Female	Male	Female	Male	
A	24	24	24	24	96
B	15	16	15	14	60
C	12	8	12	8	40
D	8	8	10	10	36
Total	59	56	61	56	232
Total	115		117		232

5.3 Learning experience

Information on students' learning experience within the human genetics units was solicited using eight items on a Likert-type scale. The eight items include the following words and phrases: *meaningful*, *enjoyable*, *stressful*, *stimulating*, *uneventful*, *sense of discovery*, *motivating* and *leads to new questions.* The average of the eight items on the learning experience scale was found and then normalized in order to compare the experience of PBL and LBC pre-clinical students. Figure 5.3 shows the histogram of the normalized scores for all students.

Figure 5.3 Pre-clinical students' perception of learning experience



Pre-clinical LBC students gave their learning experience a higher mean score (-0.10) than pre-clinical PBL students (-1.10), giving a significant mean difference (t=12.23, p=0.01). The effect size was -1.64 with a standard error of 0.15.[1] These results show that pre-clinical LBC students had a better learning experience than pre-clinical PBL students.

From the GLM univariate analysis, significant results were observed on the main factors of gender (p=0.01), teaching method (p=0.01) and university (p =0.03). Female students gained higher scores than male students within their respective groups, as indicated by the profile plot in figure 5.4.

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[1] Coe (2000) defines effect size as a way of quantifying the effectiveness of a particular intervention relative to some comparison.

Figure 5.4 Profile of learning experience across gender

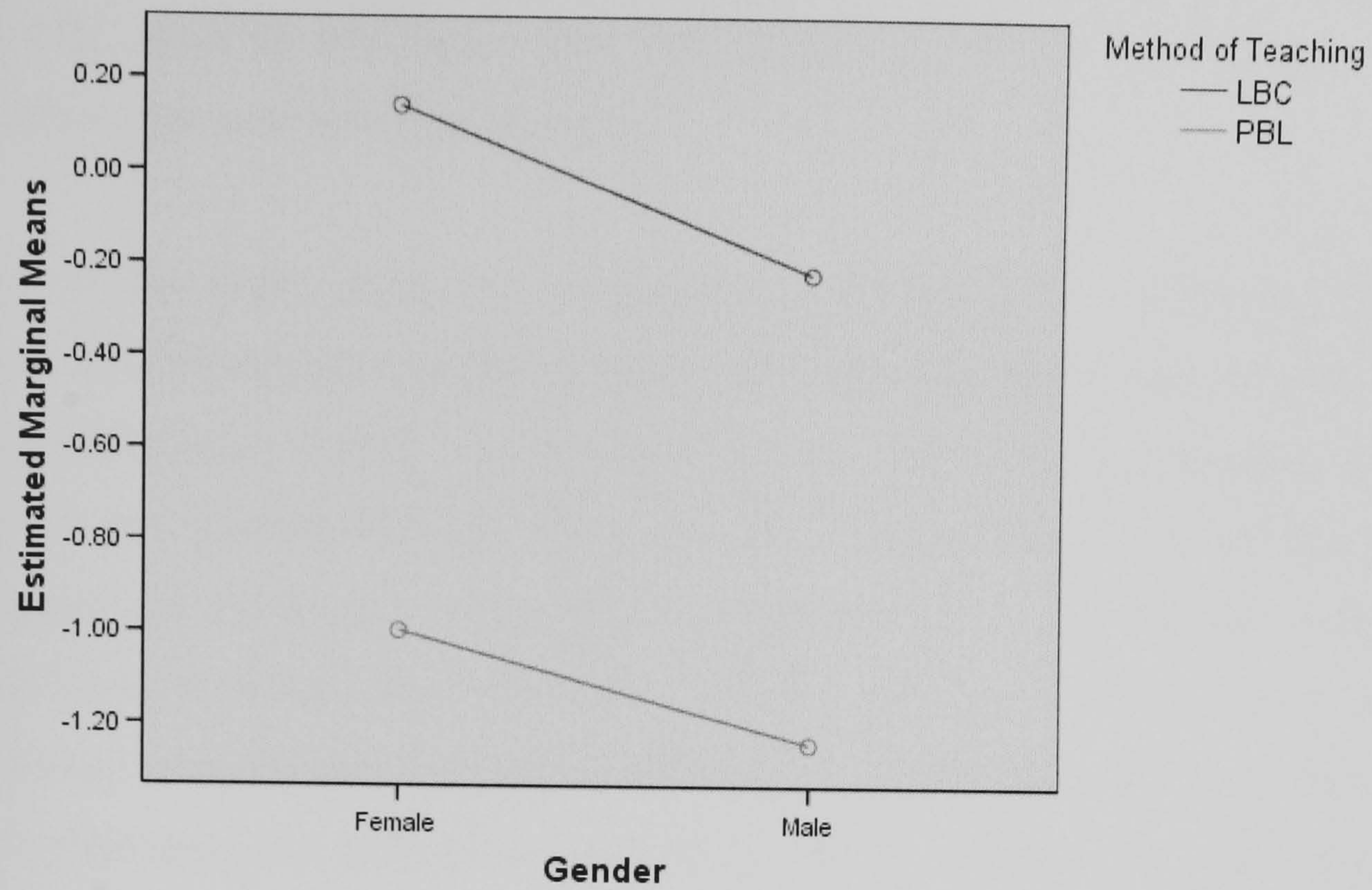


Figure 5.5 Profile of learning experience across the universities

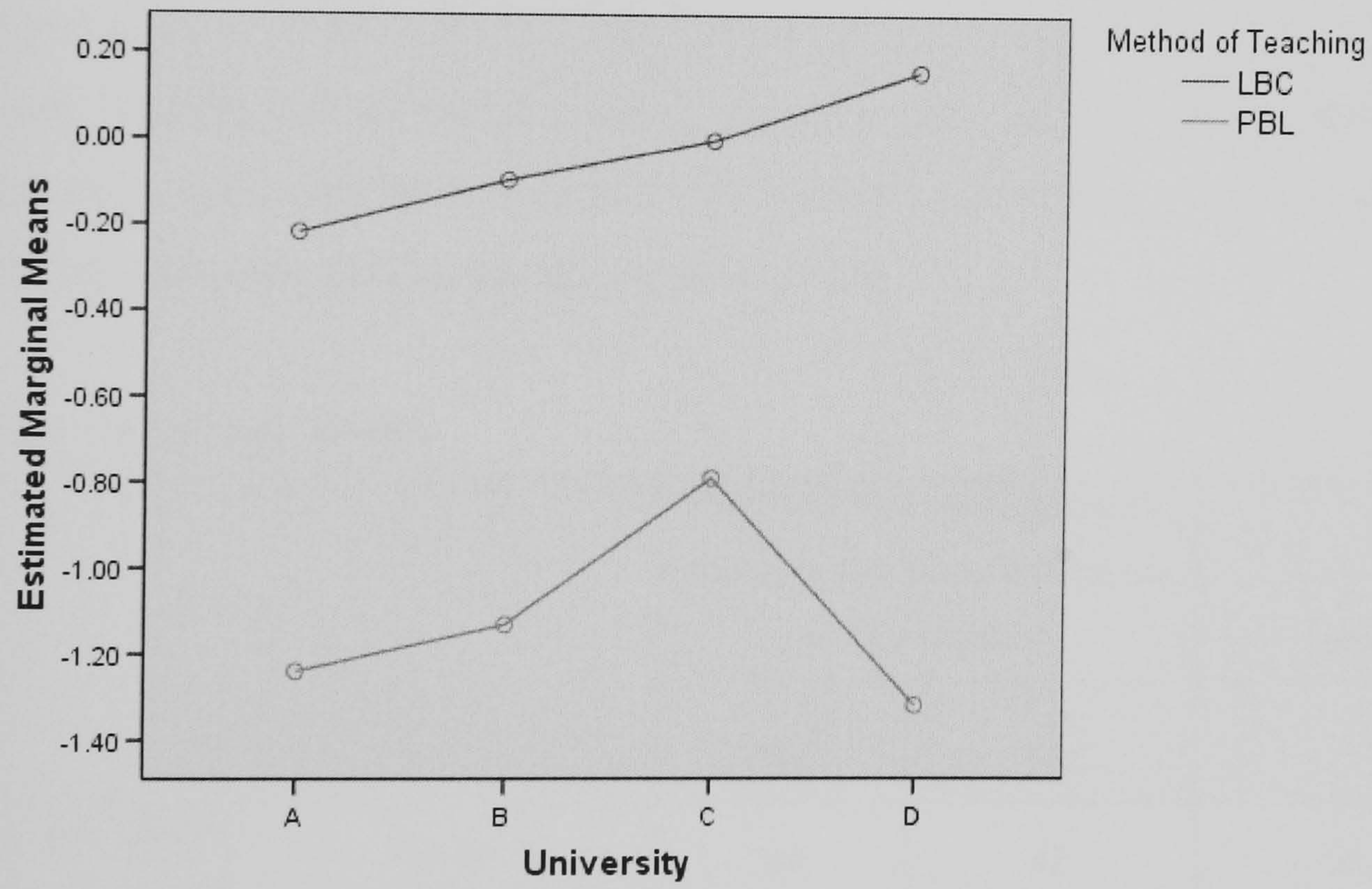


Figure 5.5, shows that in terms of learning experience, all four universities performed better with LBC compared to PBL. There were no significant two-way interactions between gender and teaching method (p=0.51) or between university and teaching method (p=0.13).

Looking at each of the eight categories under *learning experience*, the mean of the pre-clinical LBC students was higher than that of the pre-clinical PBL students. All the mean differences were also significant.

As well as the eight categories mentioned in the last few paragraphs, the DQ questionnaire solicited information from pre-clinical students on other aspects of their learning experience during the human genetics unit. The information collated considered their participation in classes, the use of case studies, and whether or not they enjoyed the experience. They were also asked if they had ever been exposed to 'problem-based learning' as an educational strategy, or if they had ever taken a course that included a significant amount of information on the molecular bases of genetic diseases, chromosomal aberrations and other genetics diseases. An analysis of the students' responses now follows.

Thirty-two percent (32%) of the pre-clinical LBC students said that they had previously participated in classes which included the use of case studies. The corresponding percentage for pre-clinical PBL students was nearly 27% (see table 5.2) the difference between the two groups is just over 4%.

Table 5.2 Use of case studies

			Have you ever participated in classes which included the use of case studies?		Total
			No	**Yes**	
Method of Teaching	**LBC**	Count	89	42	131
		% within Method of Teaching	67.9%	32.1%	100.0%
	PBL	Count	71	26	97
		% within Method of Teaching	73.2%	26.8%	100.0%
Total		Count	160	68	228
		% within Method of Teaching	70.2%	29.8%	100.0%

ChiSq=0.74, df=1, p=0.39

There was no significant association between teaching method (LBC or PBL) and whether or not case studies had been used in class; the Pearson Chi-Square statistic was found to be 0.74 with a p-value of 0.39. Overall, 29.8% (n=68) of pre-clinical students had participated in classes which included the use of case studies. Of those pre-clinical LBC students who said they had participated in classes which involved the use of case studies, only 23.5% said that they enjoyed learning in this way. The corresponding percentage for pre-clinical PBL students is lower, at 20.6% (see table 5.3), but no significant association was observed (Chi-Square statistic=0.09, p-value=0.77). Overall, of the 68 pre-clinical students that had participated in classes involving the use of case studies, 22.1% (n=15) liked learning from case studies.

Table 5.3 Number of pre-clinical students who liked learning from case studies

			If your answer to item 4 was 'YES', did you like learning from case studies?		Total
			No	Yes	
Method of Teaching	LBC	Count	26	8	34
		% within Method of Teaching	76.5%	23.5%	100.0%
	PBL	Count	27	7	34
		% within Method of Teaching	79.4%	20.6%	100.0%
Total		Count	53	15	68
		% within Method of Teaching	77.9%	22.1%	100.0%

ChiSq=0.09, df=1.0, p=0.77

Only 2.6% of pre-clinical LBC students had been previously exposed to a 'problem-based learning' educational strategy. The corresponding percentage for pre-clinical PBL students is little different at 1.8% (see table 5.4); no significant association was observed (Chi-Square statistic=0.17, p-value=0.68). Overall, only 2.2% (n=5) of pre-clinical students had previously been exposed to a 'problem-based learning' educational strategy.

Table 5.4 Problem-based learning

			Have you ever been exposed to an educational strategy identified as 'problem-based learning' before?		Total
			No	Yes	
Method of Teaching	LBC	Count	111	3	114
		% within Method of Teaching	97.4%	2.6%	100.0%
	PBL	Count	108	2	110
		% within Method of Teaching	98.2%	1.8%	100.0%
Total		Count	219	5	224
		% within Method of Teaching	97.8%	2.2%	100.0%

ChiSq=0.17, df=1.0, p=0.68

With regard to content of previous courses, the majority of the pre-clinical students, irrespective of their treatment group, had taken a course with a significant amount of information on *molecular bases of genetic diseases*, *chromosomal aberrations* and *other genetic diseases*. The percentages for pre-clinical LBC students were 92.2%, 80.9% and 79.1% respectively, whilst the corresponding percentages for pre-clinical PBL students were 96.5%, 93.0% and 84.2% respectively (see tables 5.5, 5.6 and 5.7). No significant association was observed between the treatment groups for *molecular bases of genetic diseases* (Chi-Square statistic=1.99, p-value=0.16) or *other genetic diseases* (Chi-Square statistic=0.99, p-value=0.32). For *chromosomal aberrations*, however, a significant difference was found between pre-clinical LBC and PBL students (Chi-Square statistic=7.38, p-value=0.01). A higher proportion (93.0%) of pre-clinical PBL students had taken a course with a significant amount of information on *chromosomal aberrations* than pre-clinical LBC students (80.9%).

Table 5.5 Molecular bases of genetic diseases

			Have you ever taken a course that included a significant amount of information about molecular bases of genetic diseases?		Total
			No	Yes	
Method of Teaching	LBC	Count	9	106	115
		% within Method of Teaching	7.8%	92.2%	100.0%
	PBL	Count	4	110	114
		% within Method of Teaching	3.5%	96.5%	100.0%
Total		Count	13	216	229
		% within Method of Teaching	5.7%	94.3%	100.0%

ChiSq=1.99, df=1.0, p=0.16

Table 5.6 Chromosomal aberrations

			Have you ever taken a course that included a significant amount of information about chromosomal aberrations?		Total
			No	Yes	
Method of Teaching	LBC	Count	22	93	115
		% within Method of Teaching	19.1%	80.9%	100.0%
	PBL	Count	8	106	114
		% within Method of Teaching	7.0%	93.0%	100.0%
Total		Count	30	199	229
		% within Method of Teaching	13.1%	86.9%	100.0%

ChiSq=7.38, df=1.0, p=0.01

Table 5.7 Other genetic diseases

			Have you ever taken a course that included a significant amount of information about other genetic diseases?		Total
			No	Yes	
Method of Teaching	LBC	Count	24	91	115
		% within Method of Teaching	20.9%	79.1%	100.0%
	PBL	Count	18	96	114
		% within Method of Teaching	15.8%	84.2%	100.0%
Total		Count	42	187	229
		% within Method of Teaching	18.3%	81.7%	100.0%

ChiSq=0.99, df=1.0, p=0.32

5.4 Caring experience

Information about the caring experience of pre-clinical students with respect to sickle cell anaemia and Down's syndrome was solicited. Thirty-five percent (35.1%) of pre-clinical LBC students said that they had experienced caring for persons with sickle cell anaemia, whilst the corresponding percentage for pre-clinical PBL students was 31.3% (see table 5.8). No significant association was observed (Chi-Square statistic=0.38, p-value=0.54). Overall, 33.2% of all pre-clinical students had experienced caring for persons with sickle cell anaemia.

Table 5.8 Sickle cell anaemia

			Do you have experience in caring for persons with sickle cell anaemia?		Total
			No	Yes	
Method of Teaching	LBC	Count	74	40	114
		% within Method of Teaching	64.9%	35.1%	100.0%
	PBL	Count	77	35	112
		% within Method of Teaching	68.8%	31.3%	100.0%
Total		Count	151	75	226
		% within Method of Teaching	66.8%	33.2%	100.0%

ChiSq=0.38, df=1.0, p=0.54

For Down's syndrome, 24.6% of pre-clinical LBC students had experienced caring for persons with this disease, while the corresponding percentage for pre-clinical PBL is slightly lower at 18.8% (see table 5.9): no significant association was observed (Chi-Square statistic=0.27, p-value=0.60). Overall, a lower percentage (21.7%) of all pre-clinical students had experienced caring for people with Down's syndrome than had cared for people with sickle cell anaemia (33.2%).

Table 5.9 Down's syndrome

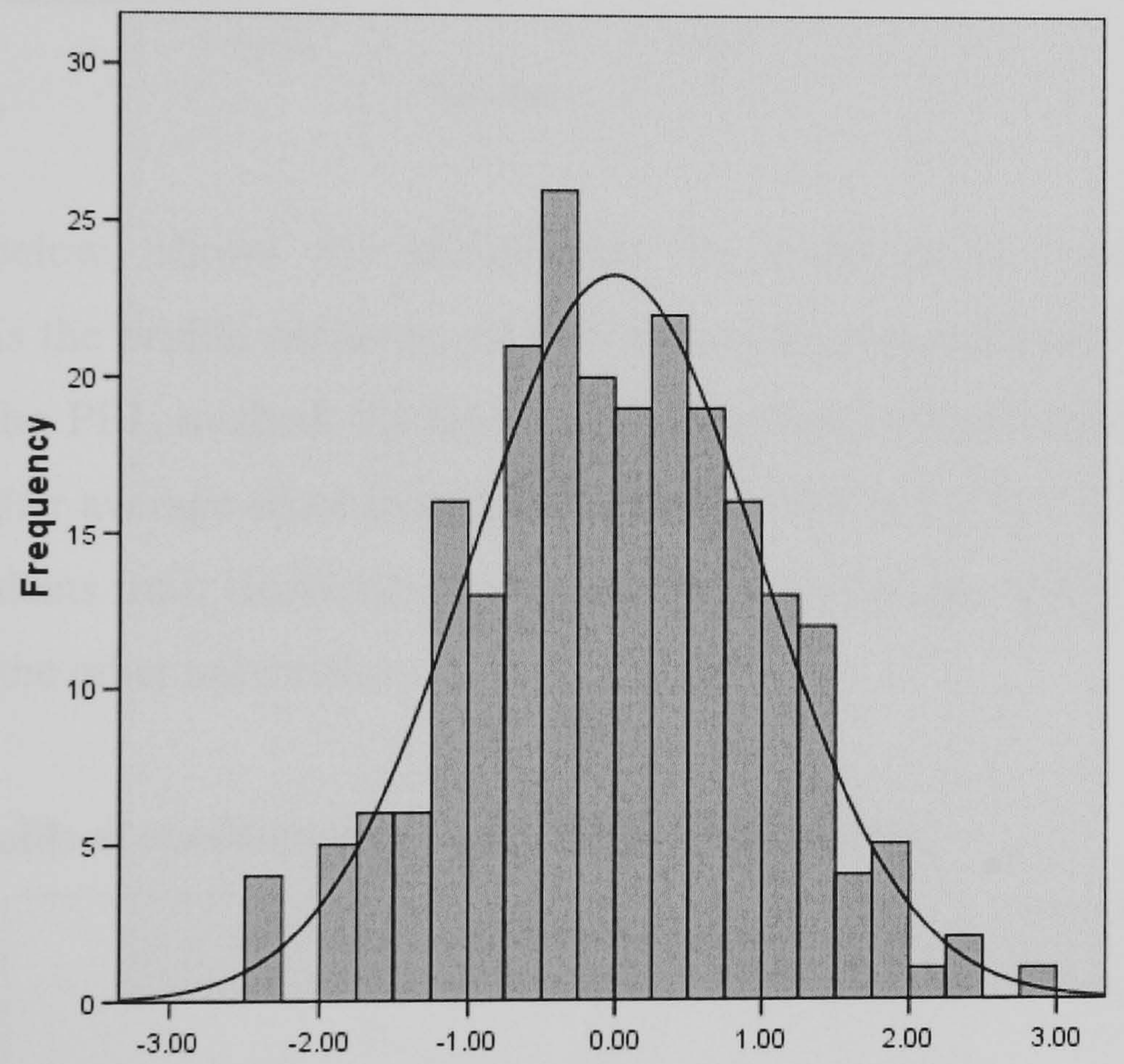
			Do you have experience in caring for persons with Down's syndrome?		Total
			No	Yes	
Method of Teaching	LBC	Count	86	28	114
		% within Method of Teaching	65.4%	24.6%	100.0%
	PBL	Count	91	21	112
		% within Method of Teaching	81.3%	18.8%	100.0%
Total		Count	177	49	226
		% within Method of Teaching	78.3%	21.7%	100.0%

ChiSq=1.12, df=1.0, p=0.29

5.5 Human genetics unit examination

Analysis from the examination data indicated that pre-clinical LBC students scored a higher mean than pre-clinical PBL students: the mean score for pre-clinical LBC students was 0.52, whereas that for pre-clinical PBL students was -0.67. The mean difference was significant (t=11.26, p=0.01).' and the effect size was -1.48 with a standard error of 0.15 (see tables 5.20 and 5.21). Thus pre-clinical LBC students achieved significantly higher marks in the examination test than pre-clinical PBL students. A histogram of the human genetics unit examination is shown in figure 5.6.

Figure 5.6 Post-exam test total for pre-clinical students



GLM univariate analysis on examination results indicates that the main factor of gender was not significant (p-value =0.31), while the main factors of teaching method (p-value=0.001) and university (p-value=0.001) were significant. The two-way interactions between gender and teaching method and between university and teaching method were not significant, having p-values of 0.07 and 0.51 respectively. The profile plot in figure 5.7 indicates that male students achieved a higher score than female students within the PBL group. Whilst female students achieved a higher score than male students for the LBC group, the differences were not significant.

Figure 5.7 Profile of examination results across gender

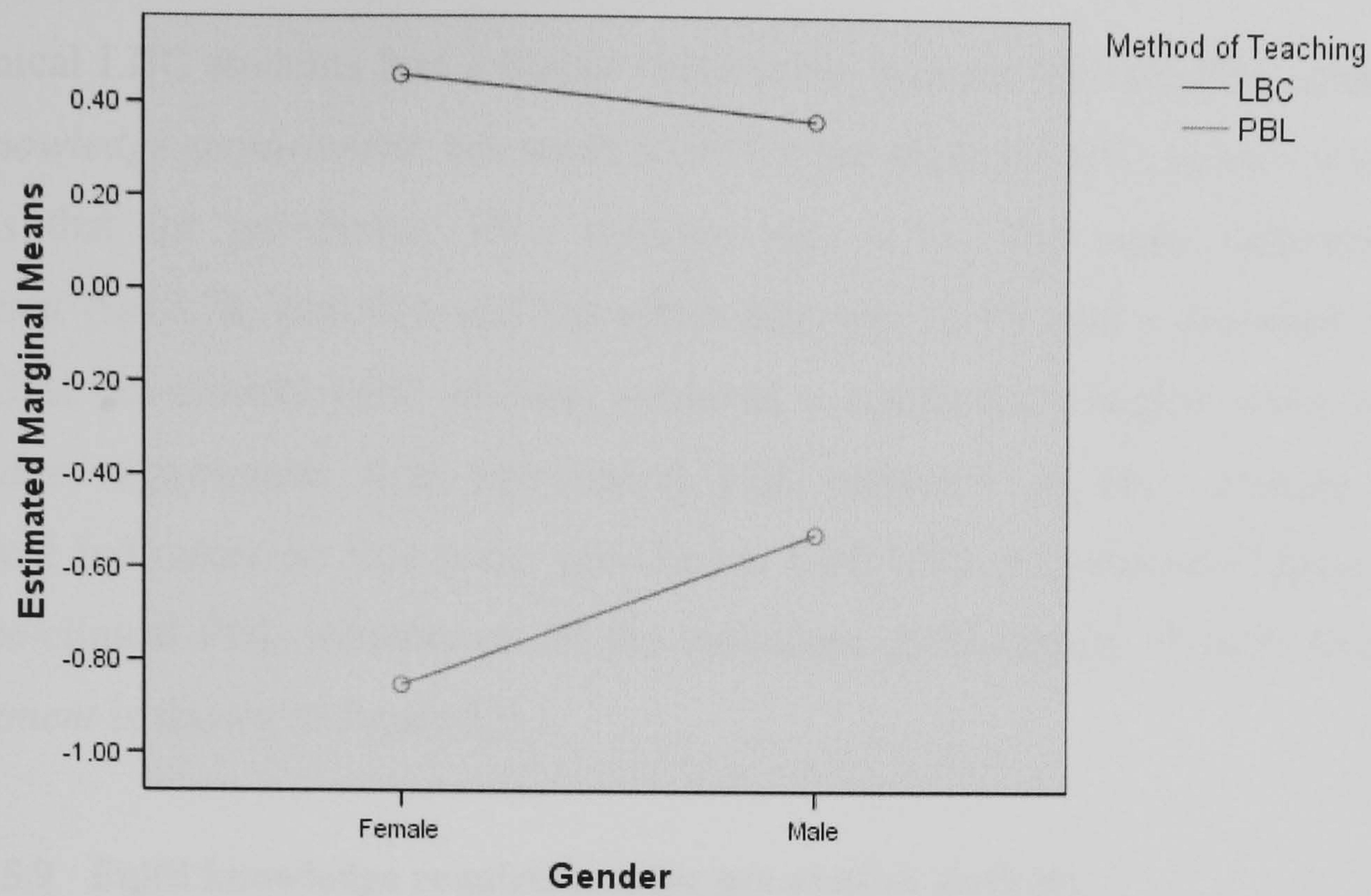
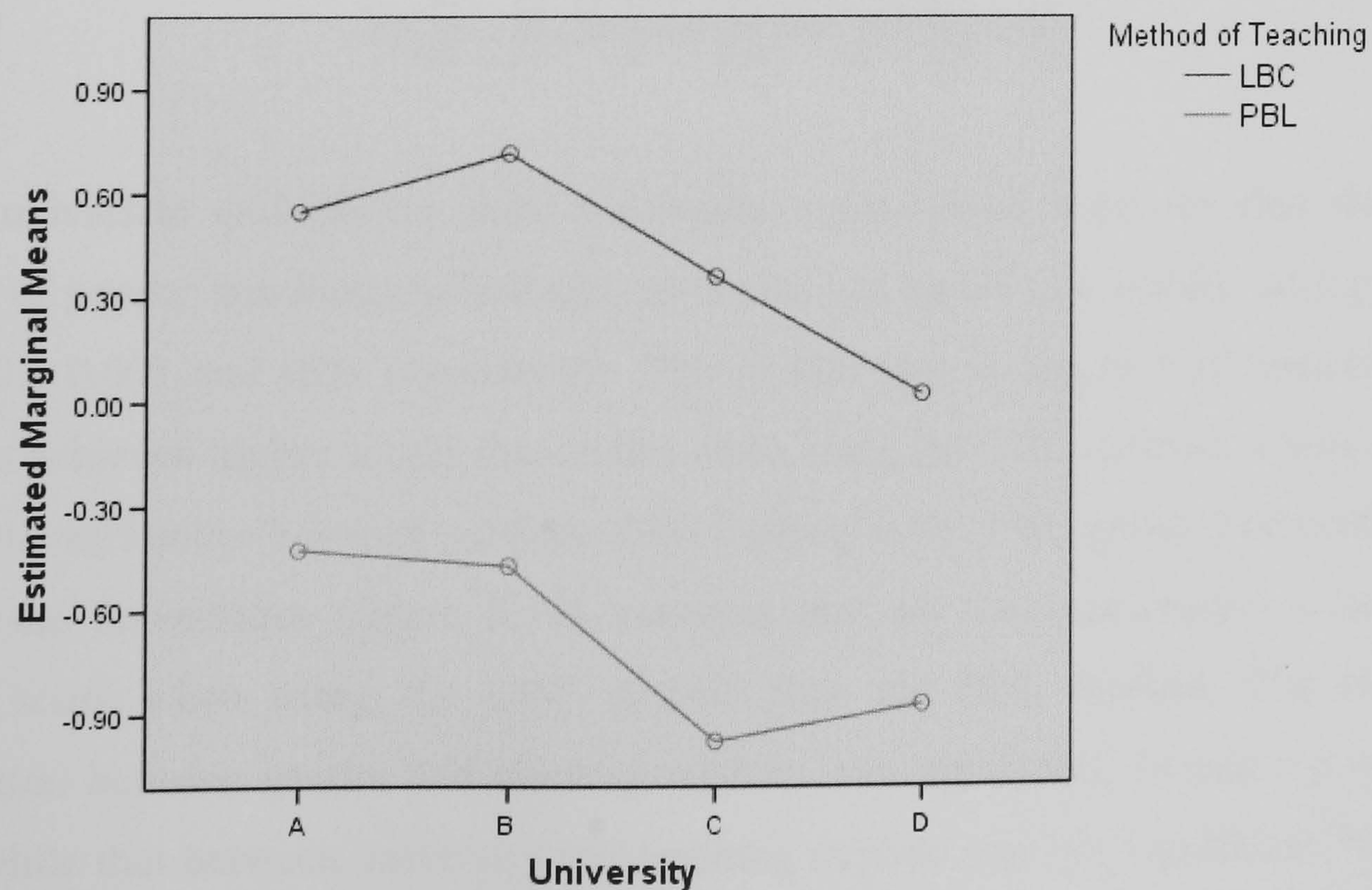


Figure 5.8, below, shows the profile plot for examination results across the universities. As the profile indicates, all four universities scored higher with the LBC method than the PBL method. As figure 5.10 indicates, students from University B achieved a higher average score using LBC than the other universities. The figure also shows that students from University A achieved a higher average score using PBL than students from the other universities.

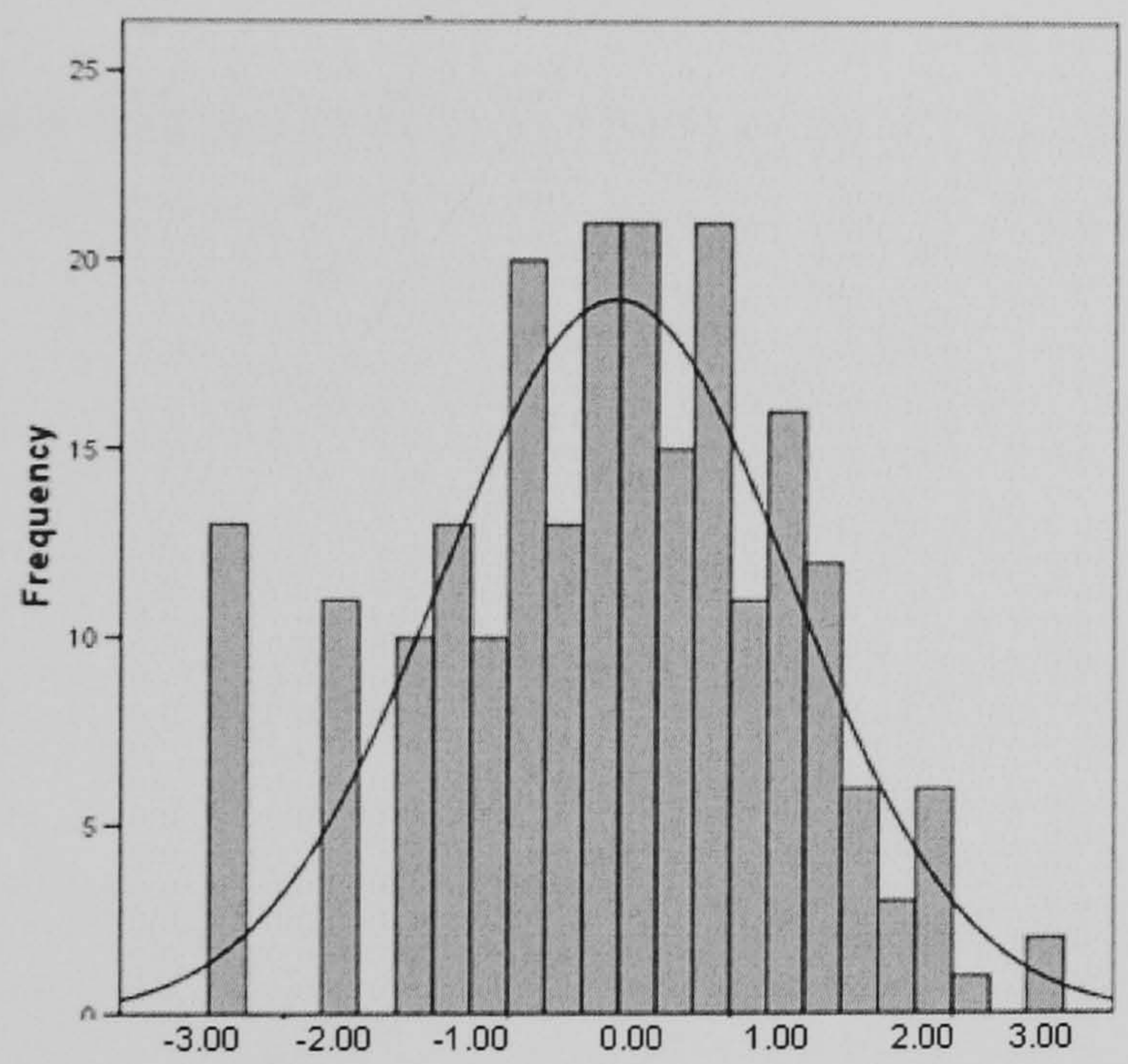
Figure 5.8 Profile of examination results across the universities



5.6 Fulfil knowledge requirement

Pre-clinical LBC students had a higher mean score than pre-clinical PBL students on *fulfil knowledge requirement*: the mean score for pre-clinical LBC students was -0.08, whereas that for pre-clinical PBL students was -1.12. The mean difference was significant (t=12.78, p=0.01), and the effect size was -1.75 with a standard error of 0.16. Thus pre-clinical LBC students achieved a significantly higher score on *fulfil knowledge requirement* than pre-clinical PBL students. In fact, looking at the individual indicators on this scale, pre-clinical LBC students achieved higher scores than pre-clinical PBL students on all the indicators. A histogram of *fulfil knowledge requirement* is shown in figure 5.9.

Figure 5.9 Fulfil knowledge requirement for pre-clinical students



GLM univariate analysis on *fulfil knowledge requirement* indicates that the main factors of gender, teaching method and university had significant results, with p-values of 0.001, 0.001 and 0.01 respectively. The profile plot in figure 5.10 indicates that females achieved higher scores than males when using the LBC method, whilst there is very little difference between genders when looking at the PBL group. The profile plot across the universities (figure 5.11) indicates that all four universities achieved a higher score when using the LBC method than the PBL method. The two-way interaction between gender and teaching method was significant, having a p-value of 0.01, while that between university and teaching method was not significant, having a p-value of 0.24.

Figure 5.10 Profile plot of fulfil knowledge requirement across gender

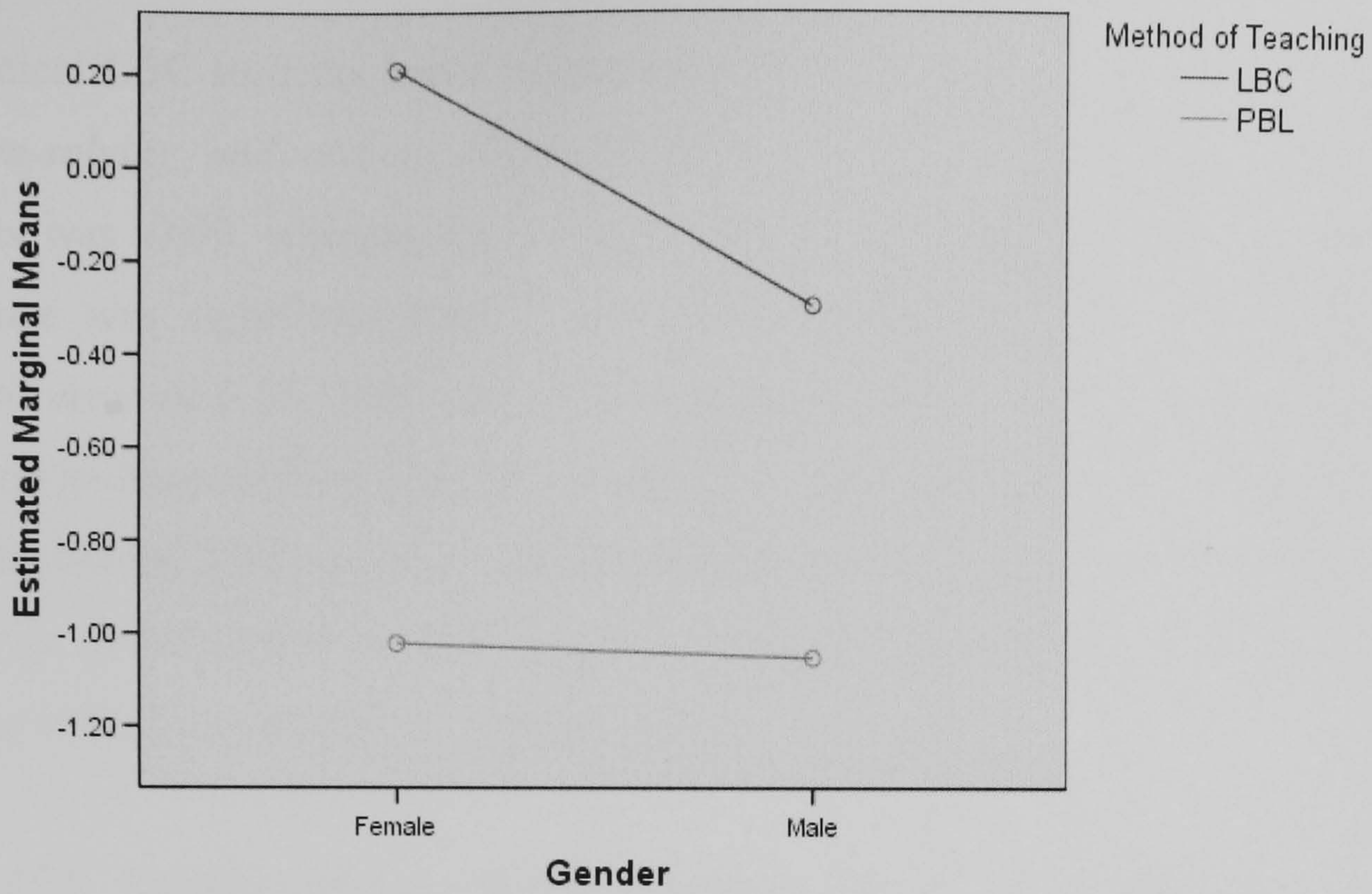
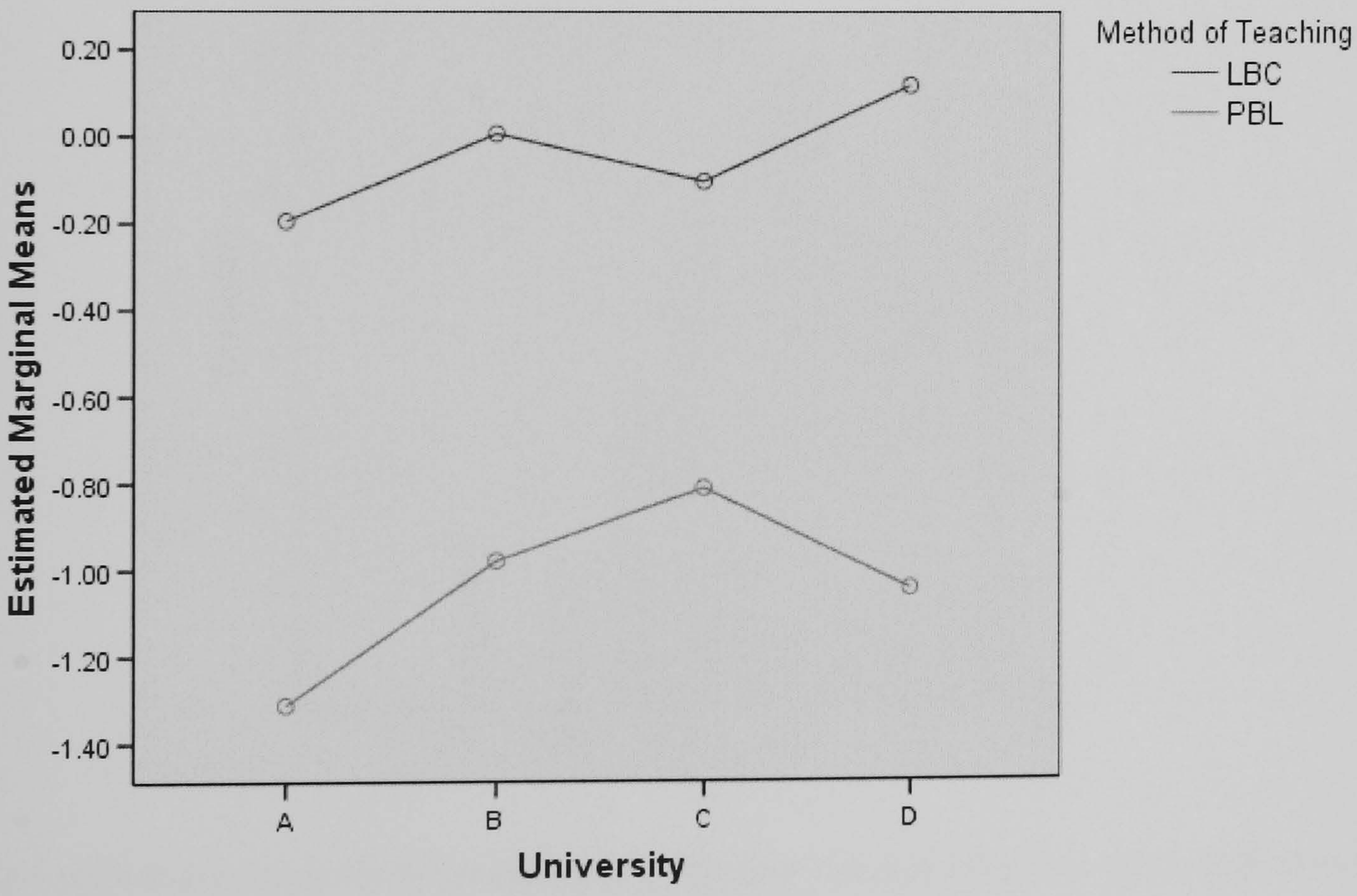


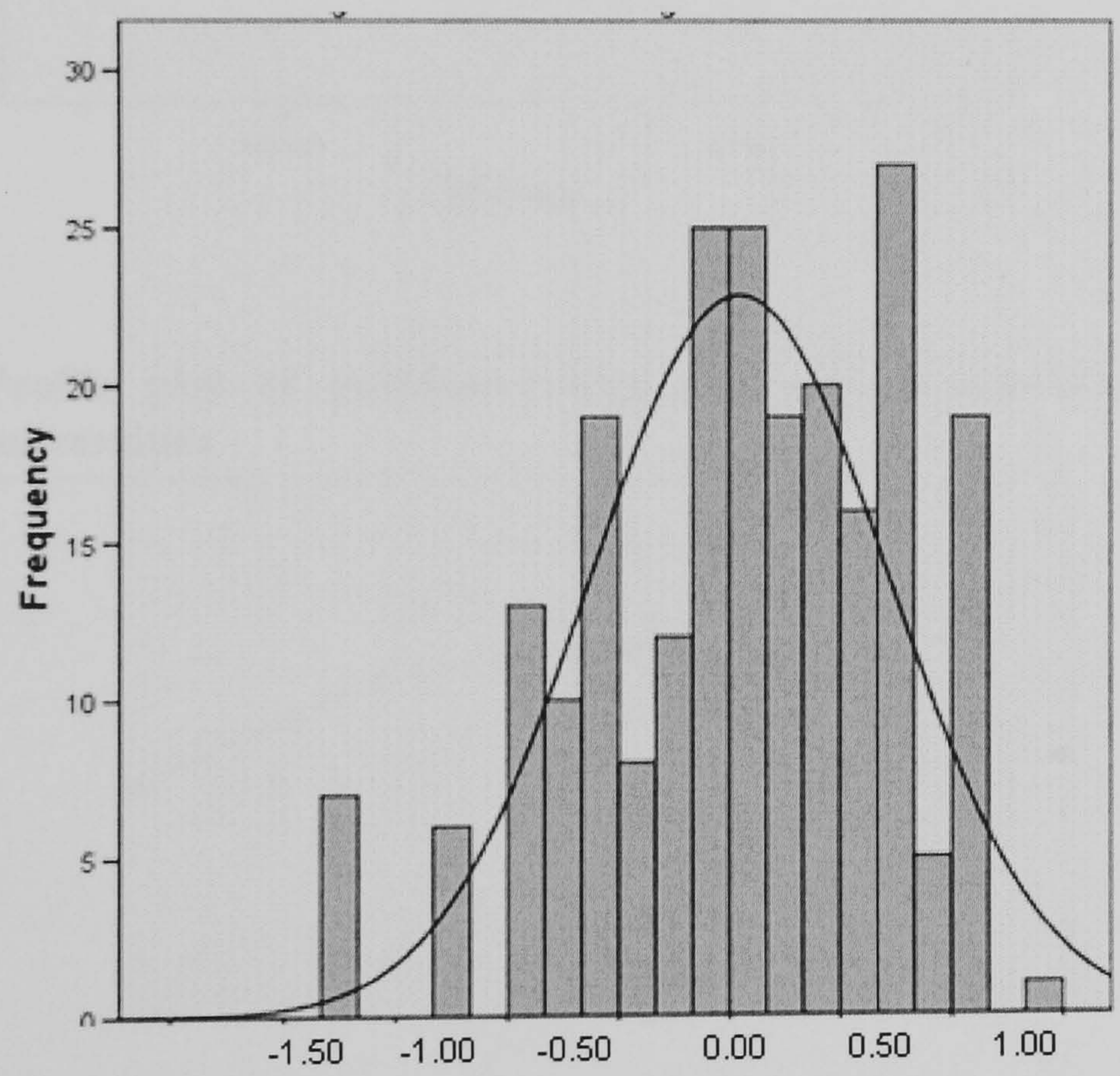
Figure 5.11 Profile plot of fulfil knowledge requirement across the universities



5.7 Problem-solving and critical thinking skills

Pre-clinical LBC students had a higher mean score than pre-clinical PBL students on *problem-solving and critical thinking skills*: the mean score for pre-clinical LBC students was -0.09, whereas that for pre-clinical PBL students was -0.93. The mean difference was significant (t=9.44, p=0.01), and the effect size was -1.58 with a standard error of 0.15. Thus pre-clinical LBC students achieved significantly higher scores on *problem-solving and critical thinking skills* than pre-clinical PBL students. In fact, pre-clinical LBC students achieved higher scores than pre-clinical PBL students on all six of the items on this scale. A histogram of *problem-solving and critical thinking skills* is shown below in figure 5.12.

Figure 5.12 Problem-solving and critical thinking skills for pre-clinical students



GLM univariate analysis of *problem-solving and critical thinking skills* indicates that the main factors of gender, teaching method and university all had significant results, each with p-values of 0.001. The profile plot in figure 5.13 indicates that females achieved higher scores than males with both LBC and PBL; this difference was more noticeable, however, with LBC than with PBL. Thus females using the LBC method had better *problem-solving and critical thinking skills* than males. The profile plot across the universities (figure 5.14) indicates that students in all four universities achieved a higher score when using the LBC method rather than the PBL method. The two-way interactions between gender and teaching method and between university and teaching method were significant, having p-values of 0.02 and 0.02 respectively.

Figure 5.13 Profile plot of problem-solving and critical thinking skills across gender

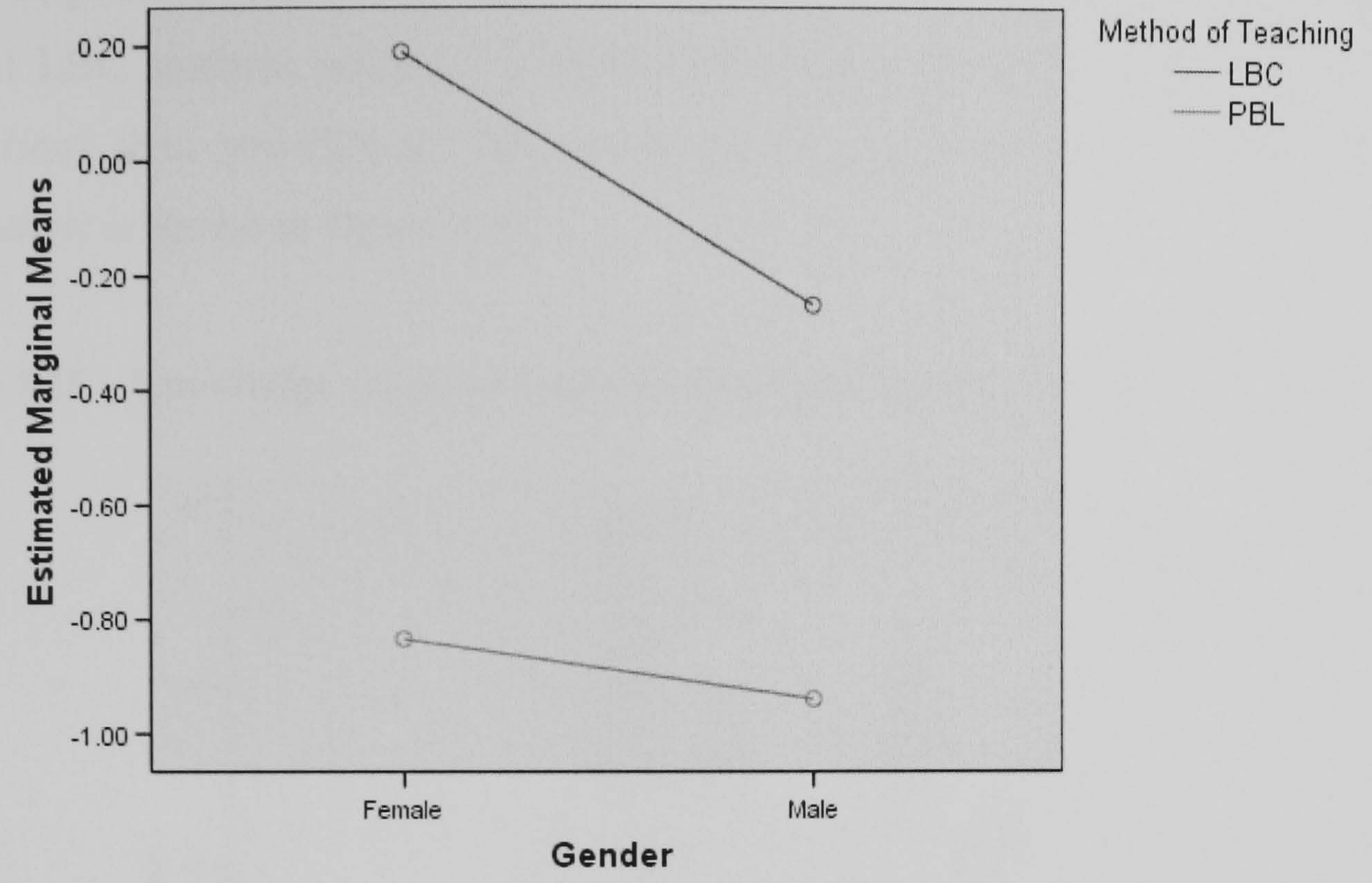
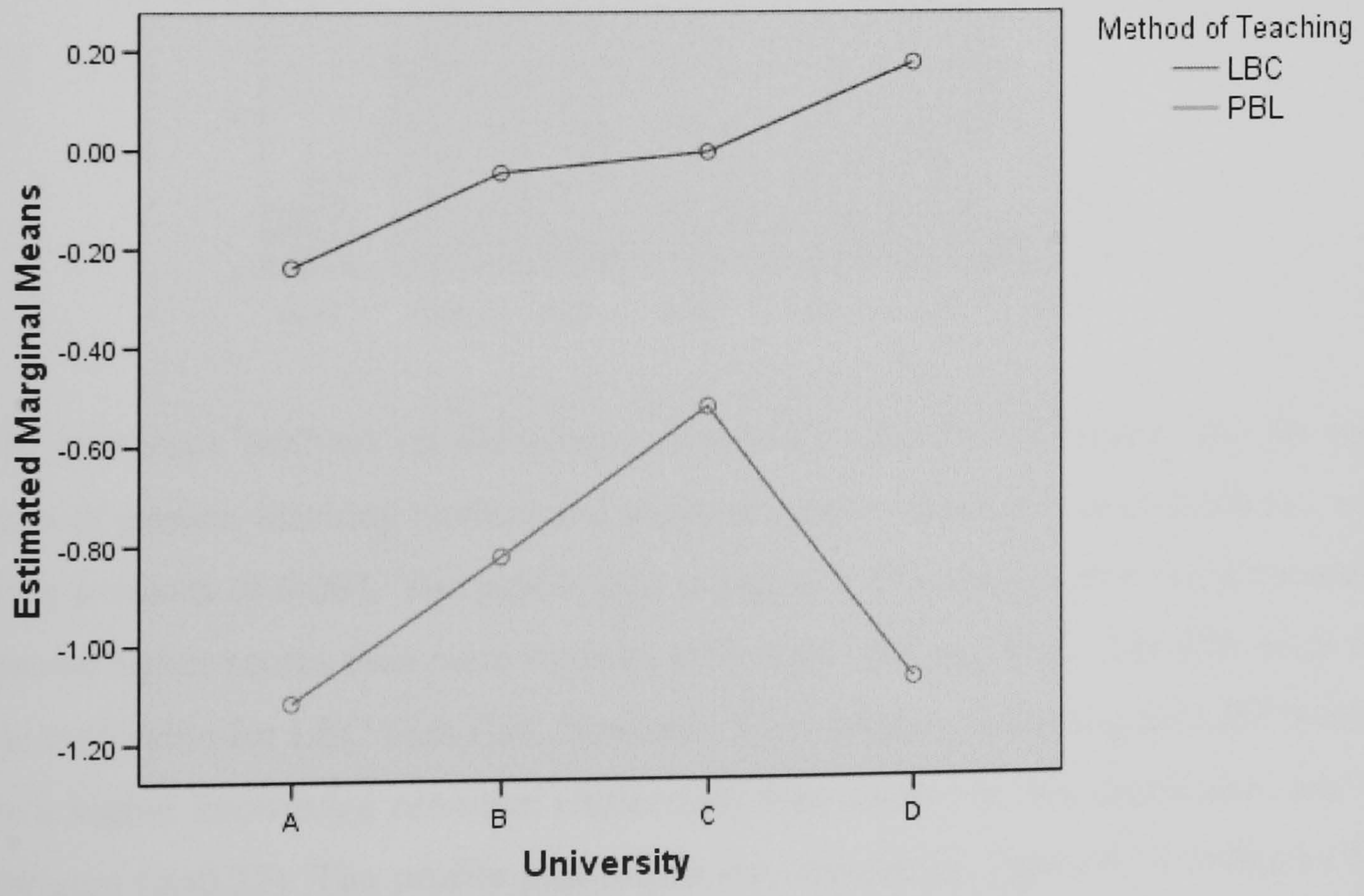


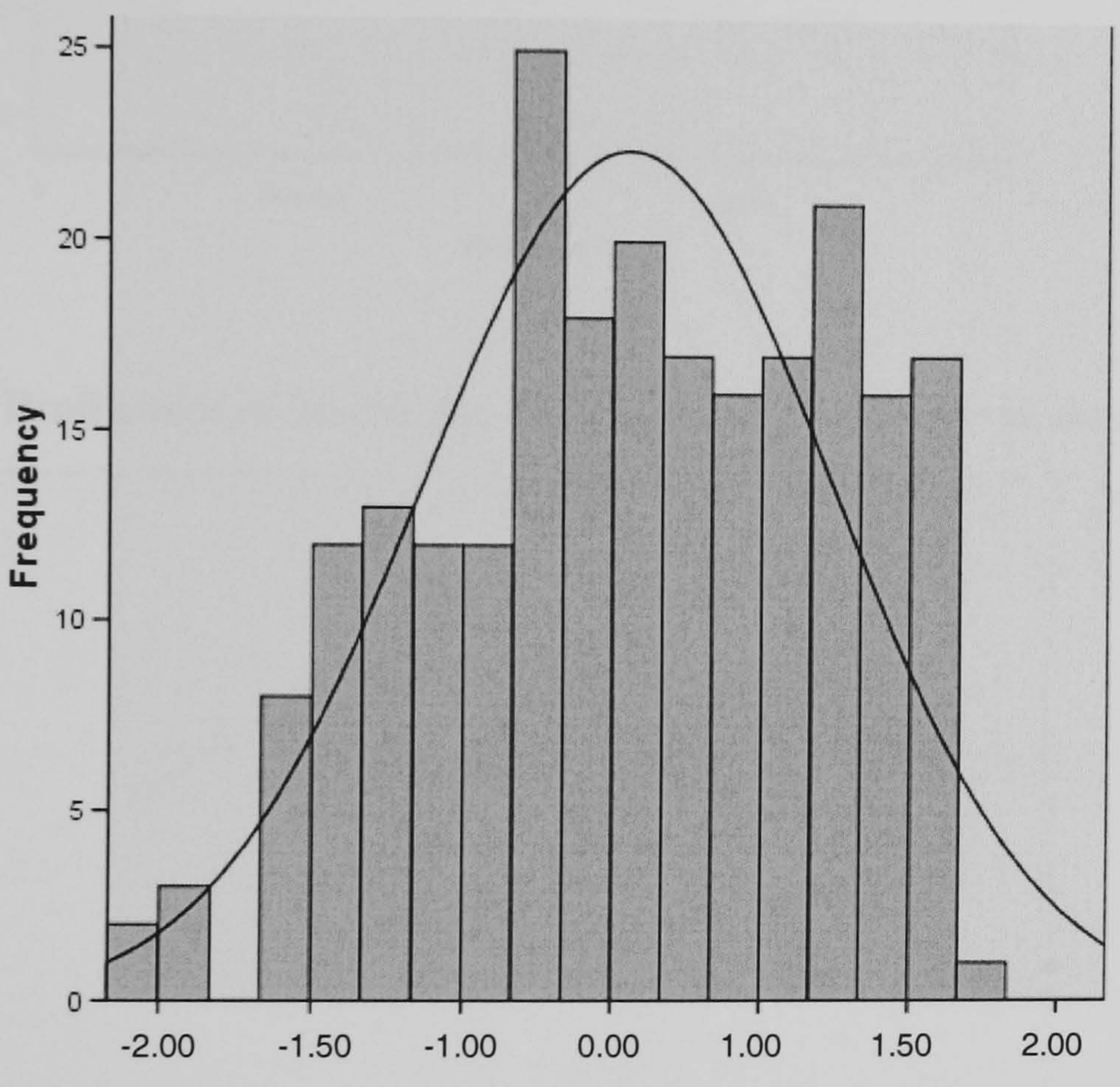
Figure 5.14 Profile plot of problem-solving and critical thinking skills across the universities



5.8 Knowledge retention (reflection)

Pre-clinical LBC students (-0.08) had a higher mean score than pre-clinical PBL (-0.94) students on *knowledge retention (reflection)*, with a significant mean difference (t=12.08, p=0.01). The effect size was -1.64 with a standard error of 0.15. Thus pre-clinical LBC students achieved a significantly higher score on *knowledge retention (reflection)* than pre-clinical PBL students. A histogram of *knowledge retention (reflection)* is shown in figure 5.15.

Figure 5.15 Knowledge retention (reflection) for pre-clinical students



GLM univariate analysis on *knowledge retention (reflection)* indicates that the main factors of gender, teaching method and university have results that are significant, each having p-values of 0.001. The profile plot in figure 5.16 indicates that female students achieved higher scores than male students with both LBC and PBL; this difference was more noticeable for LBC than PBL, however. Thus females following the LBC method have a higher *knowledge retention (reflection)* than males but this interaction was not significant (p=0.22). The profile plot across the universities figure 5.17 indicates that students in all four universities achieved a higher score when using the LBC method rather than the PBL method. The two-way interaction between the university and teaching method was not significant, having p-values of 0.57.

Figure 5.16 Profile plot of knowledge retention (reflection) across gender

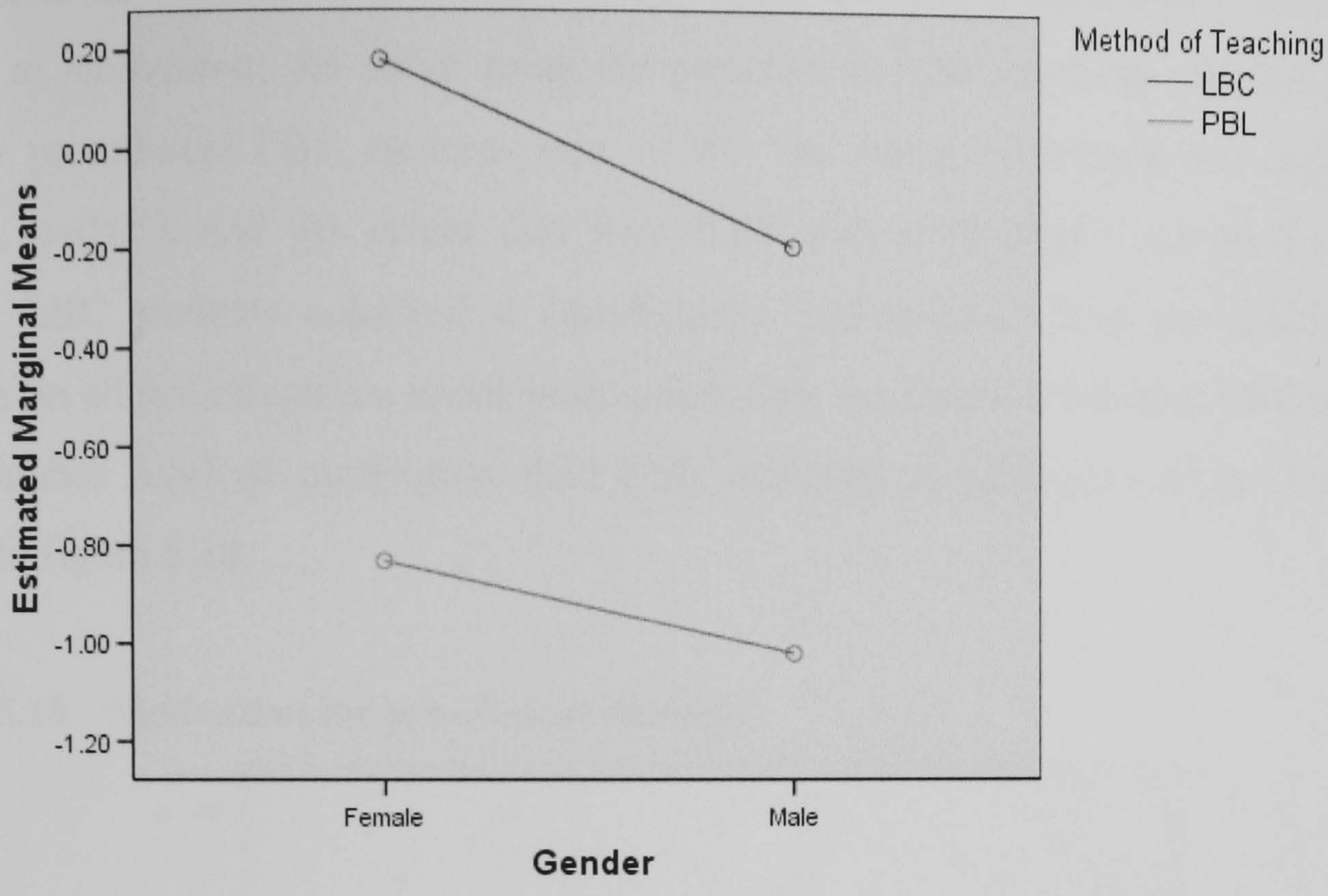
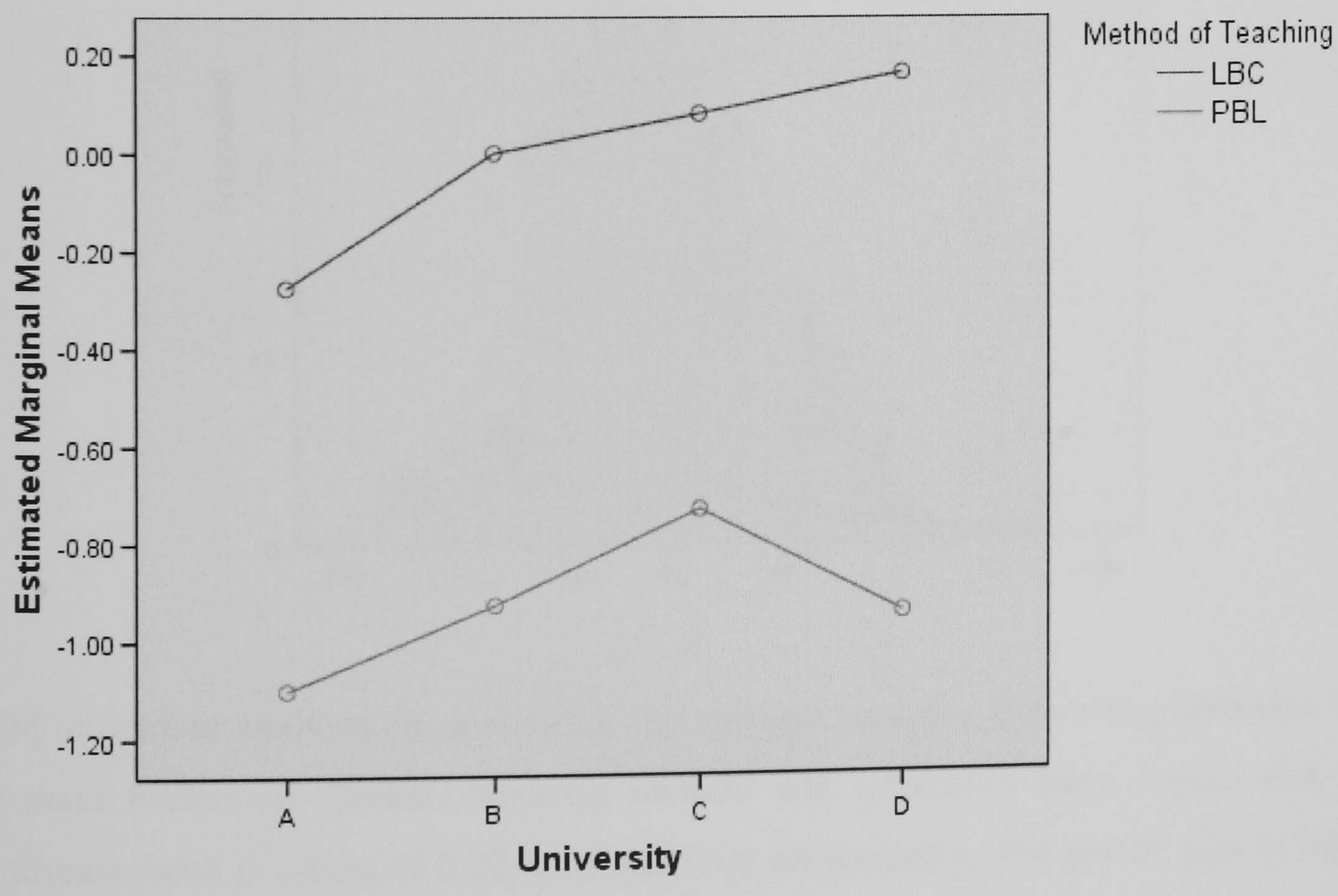


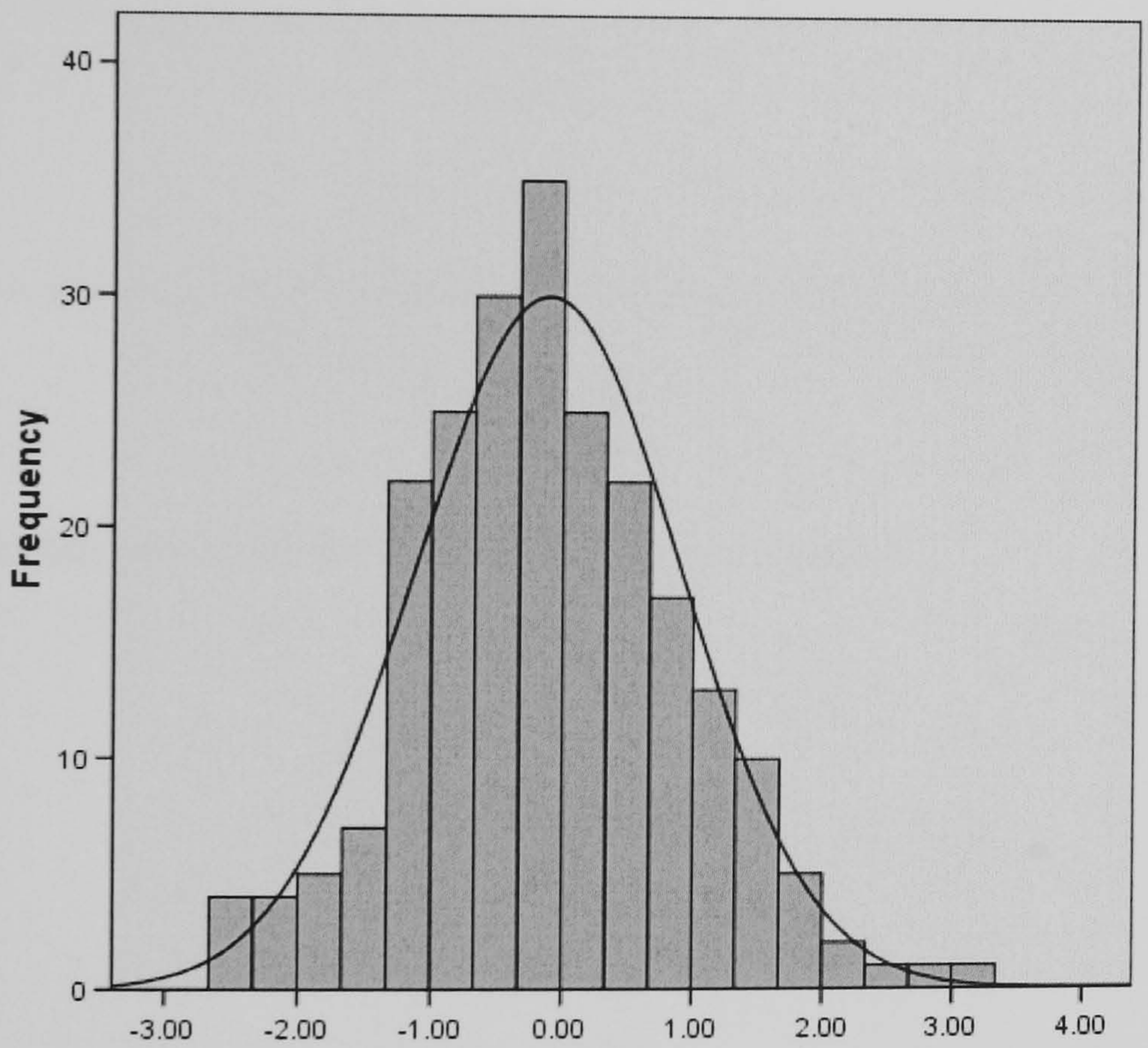
Figure 5.17 Profile plot of knowledge retention (reflection) across the universities



5.9 Motivation and intrinsic interest in learning

Pre-clinical LBC students had a higher mean score than pre-clinical PBL students with respect to *motivation*: the mean score for pre-clinical LBC students was 0.22, while that for pre-clinical PBL students was -0.56. The mean difference was significant (t=6.32, p=0.01), and the effect size was -0.84 with a standard error of 0.14. Pre-clinical LBC students achieved a significantly higher score than pre-clinical PBL students on all ten categories under *motivation*; thus the results show that LBC students had a higher level of motivation than PBL students. A histogram of *motivation* is shown in figure 5.18.

Figure 5.18 Motivation for pre-clinical students



GLM univariate analysis on *motivation and intrinsic interest in learning* indicates that the main factors of gender, teaching method and university have results that are significant, with p-values of 0.02, 0.01 and 0.01 respectively. The profile plot in figure 5.19 indicates that female students achieved a higher score than male students on both LBC and PBL methods; this difference was more noticeable with LBC than PBL, however. Thus female students had a higher level of *motivation and intrinsic interest in learning* than male students on the LBC method. The profile plot across the universities (figure 5.20) indicates that students in all four universities achieved a higher score when using the LBC method rather than the PBL method. The two-way interaction between gender and teaching method was not significant (p=0.19), whereas the two-way interaction between university and teaching method was significant, having a p-value of 0.01.

Figure 5.19 Profile plot of motivation across gender

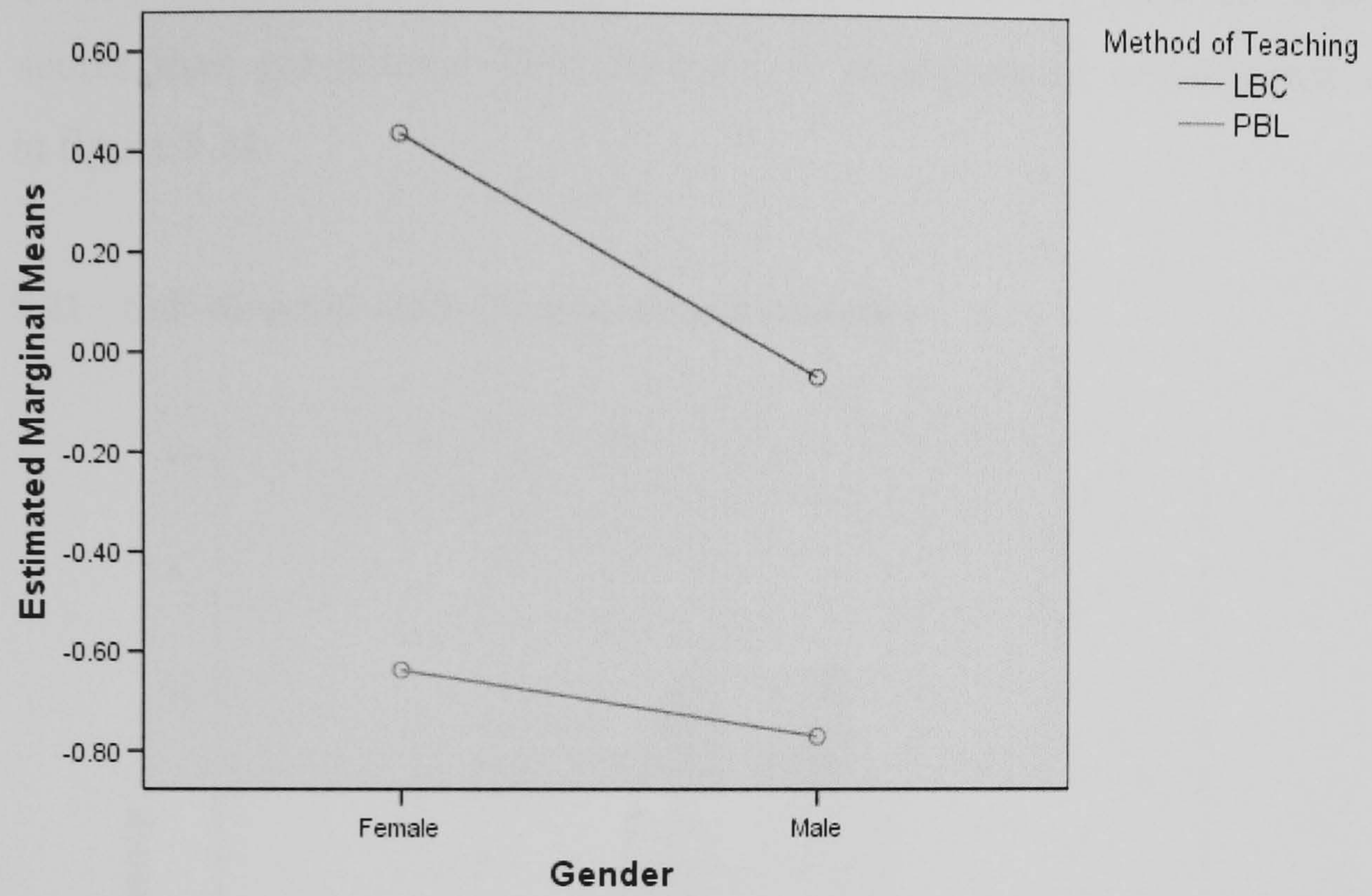
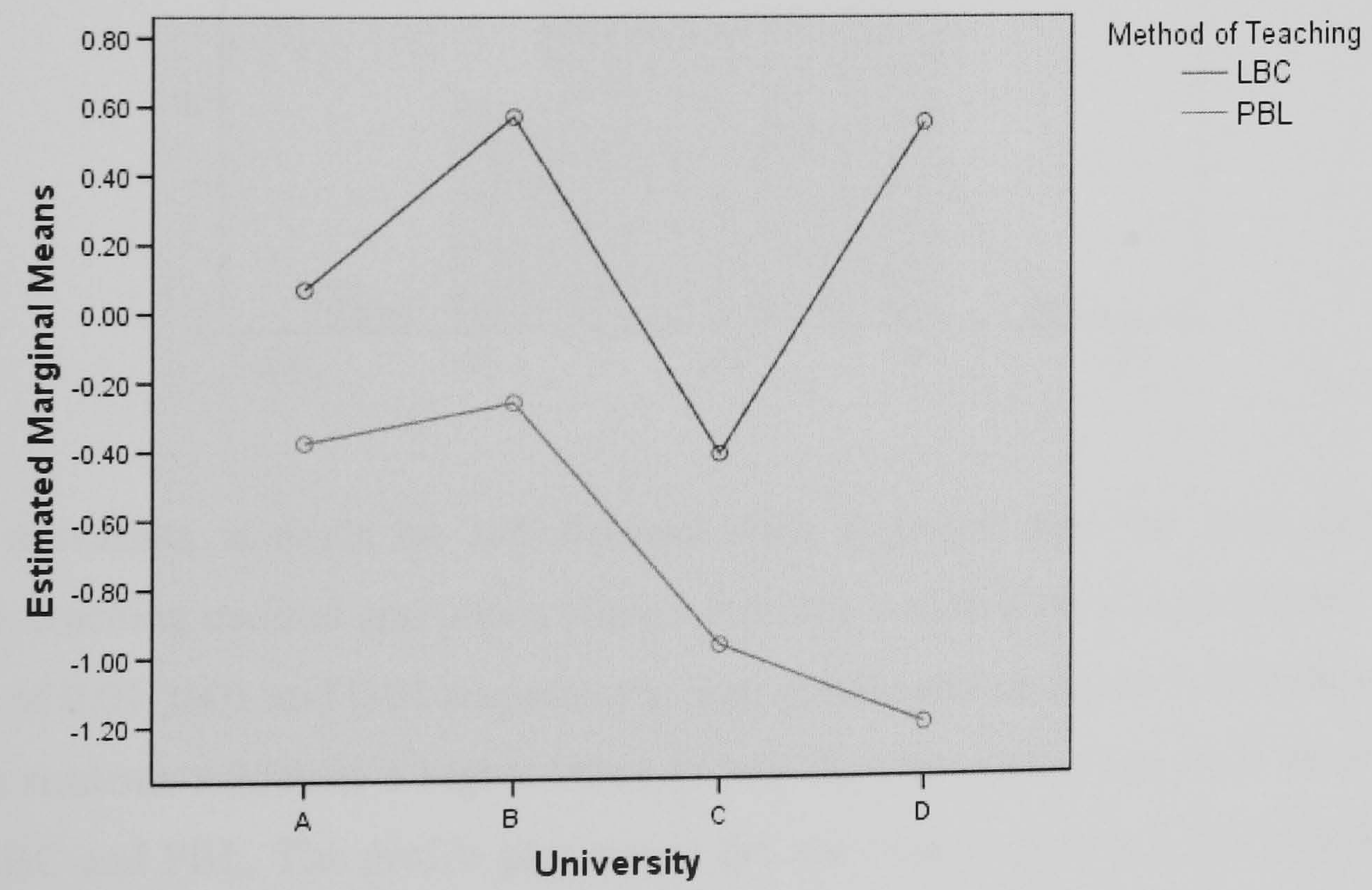


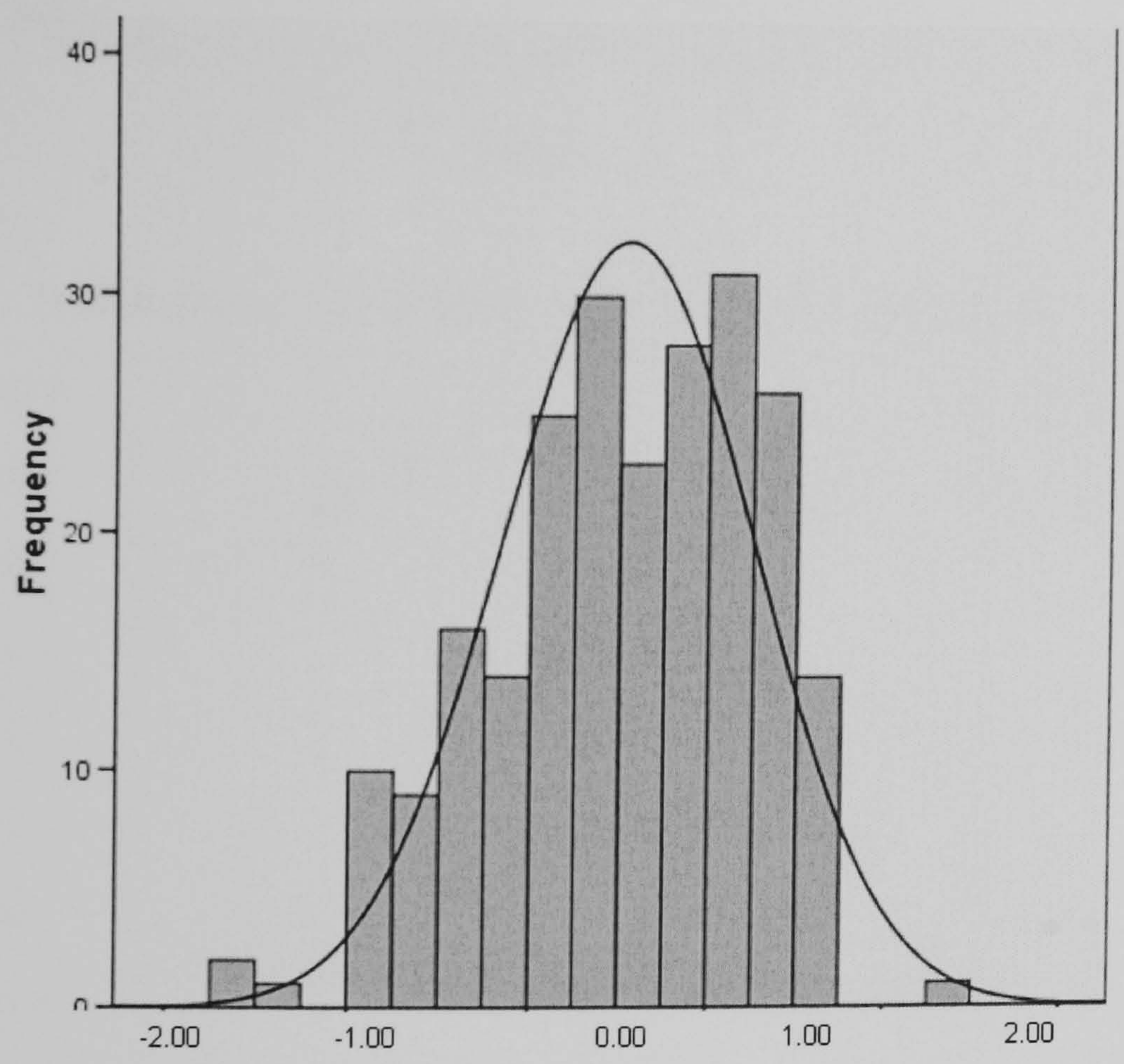
Figure 5.20 Profile plot of motivation across the universities



5.10 Self-directed skills

Pre-clinical LBC students had a higher mean score (-0.04) than pre-clinical PBL students (-0.99) on *self-directed skills*. The mean difference was significant (t=13.63, p=0.01); the effect size was -1.80 with a standard error of 0.16. In fact, for all the eight categories under *self-directed skills,* pre-clinical LBC students achieved significantly higher scores than pre-clinical PBL students. A histogram of *self-directed skills* is shown in figure 5.21.

Figure 5.21 Self-directed skills for pre-clinical students



GLM univariate analysis on *self-directed skills* indicates that the main factors of gender, teaching method and university gave results which were all significant, with p-values of 0.01, 0.01 and 0.01 respectively. The profile plot in figure 5.22 indicates that female students achieved a higher score in *self-directed skills* than male students for both LBC and PBL. The profile plot across the universities (figure 5.23) indicates that students in all four universities achieved a higher score when using the LBC method rather than the PBL method. The two-way interactions between gender and teaching method and between university and teaching method were not significant (p-values of 0.43 and 0.16 respectively).

Figure 5.22 Profile plot of self-directed skills across gender

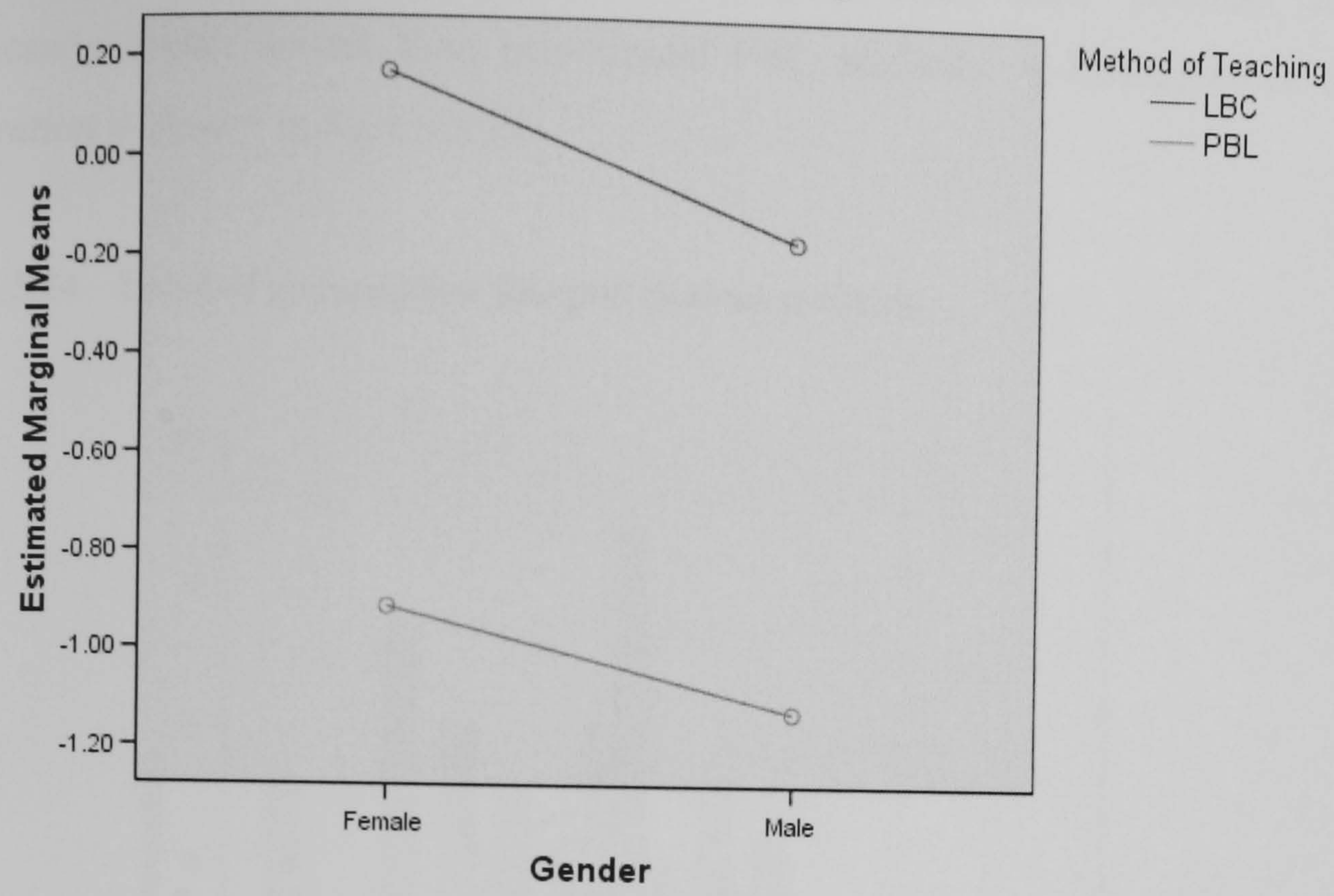
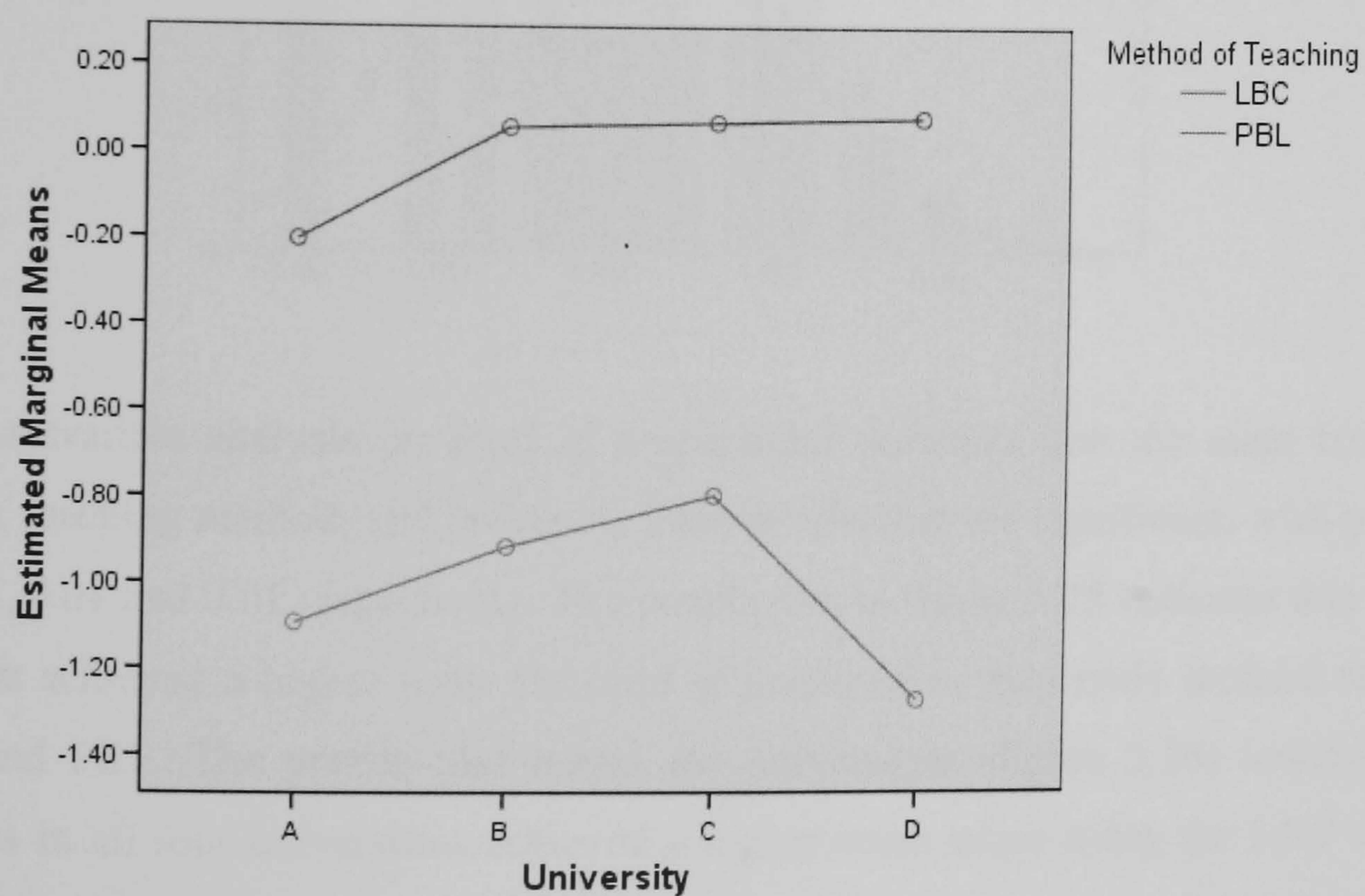


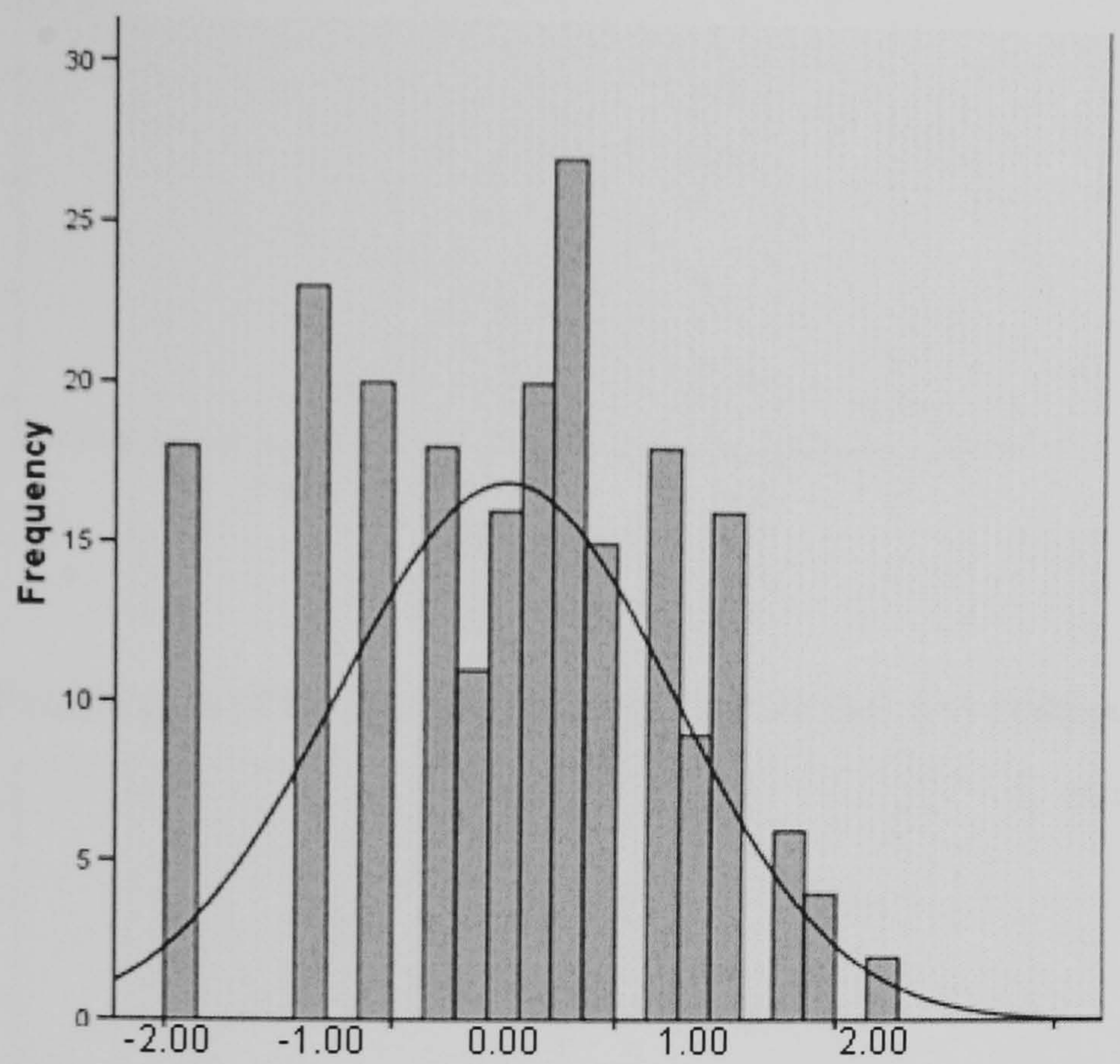
Figure 5.23 Profile plot of self-directed skills across the universities



5.11 Level of preparation

Pre-clinical LBC students had a higher mean score (-0.10) than pre-clinical PBL students (-1.04) on *level of preparation*. The mean difference was significant (t=11.50, p=0.01); the effect size was -1.58, with a standard error of 0.15. Thus pre-clinical LBC students were, or felt, better prepared than pre-clinical PBL students (whether preparing alone, with other students, regularly or irregularly). In fact, for all three of the categories under *level of preparation,* pre-clinical LBC students achieved significantly higher scores than pre-clinical PBL students. A histogram of *level of preparation* is shown in figure 5.24.

Figure 5.24 Level of preparation for pre-clinical students



GLM univariate analysis on *level of preparation* indicates that the main factors of gender, teaching method, and university have results that are significant, with p-values of 0.01, 0.01 and 0.01 respectively. The profile plot in figure 5.25 indicates that female students achieved a higher score for *level of preparation* than male students for both LBC and PBL. The profile plot across the universities (figure 5.26) indicates that students in all four universities achieved a higher score when using the LBC method rather than the PBL method. The two-way interactions between gender and teaching method and between university and teaching method were not significant, having p-values of 0.80 and 0.44 respectively.

Figure 5.25 Profile plot of level of preparation across gender

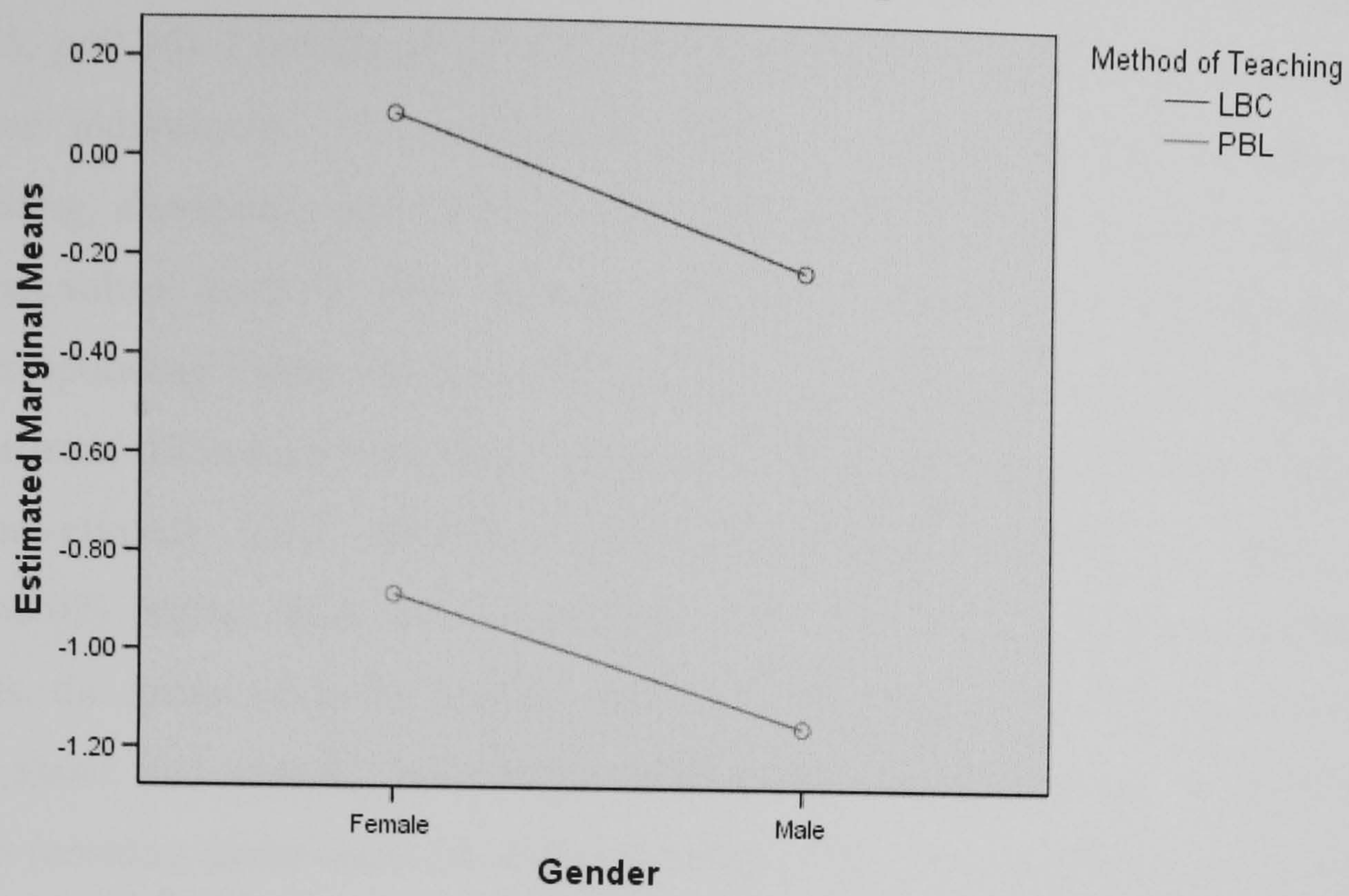
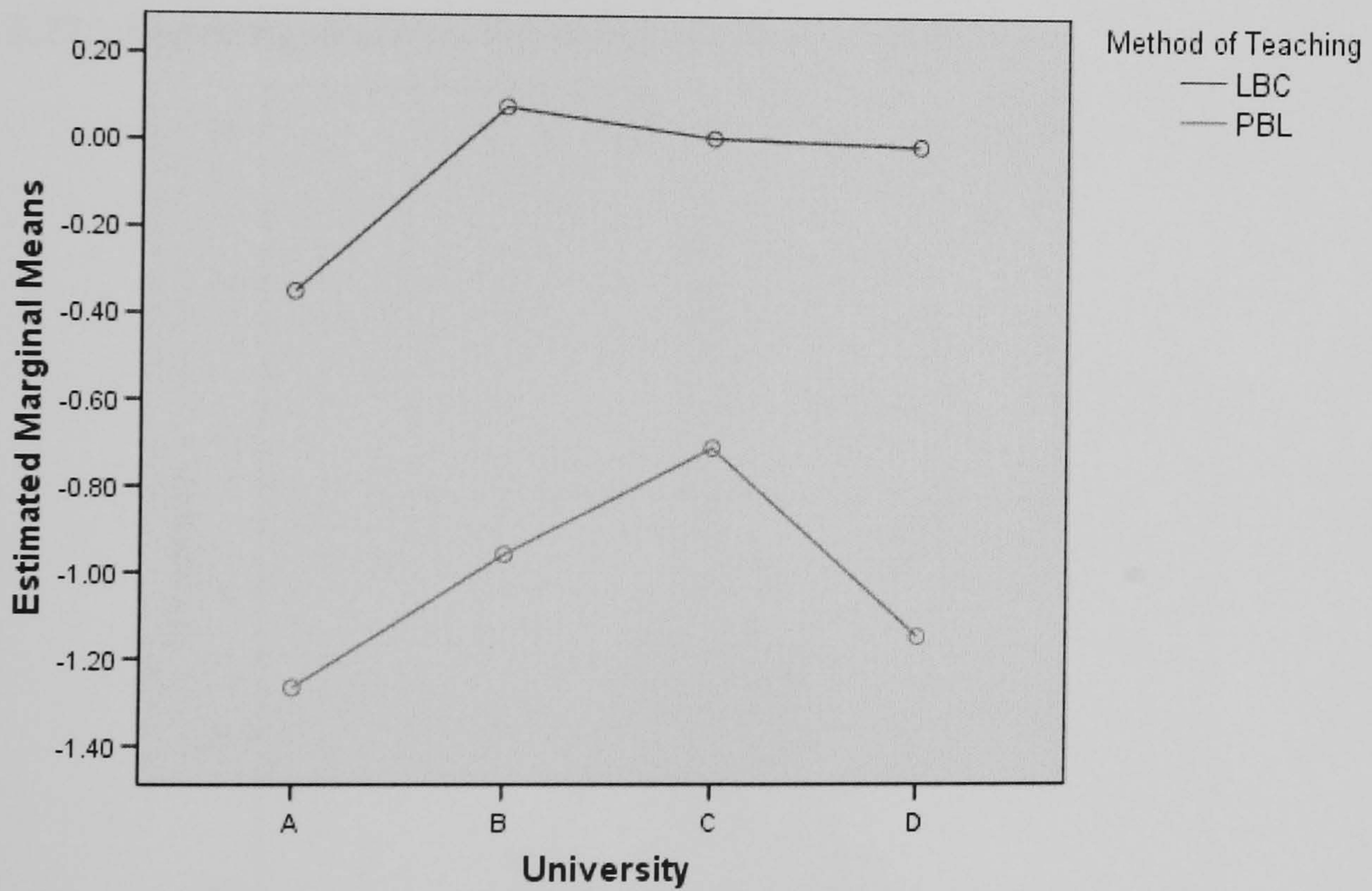


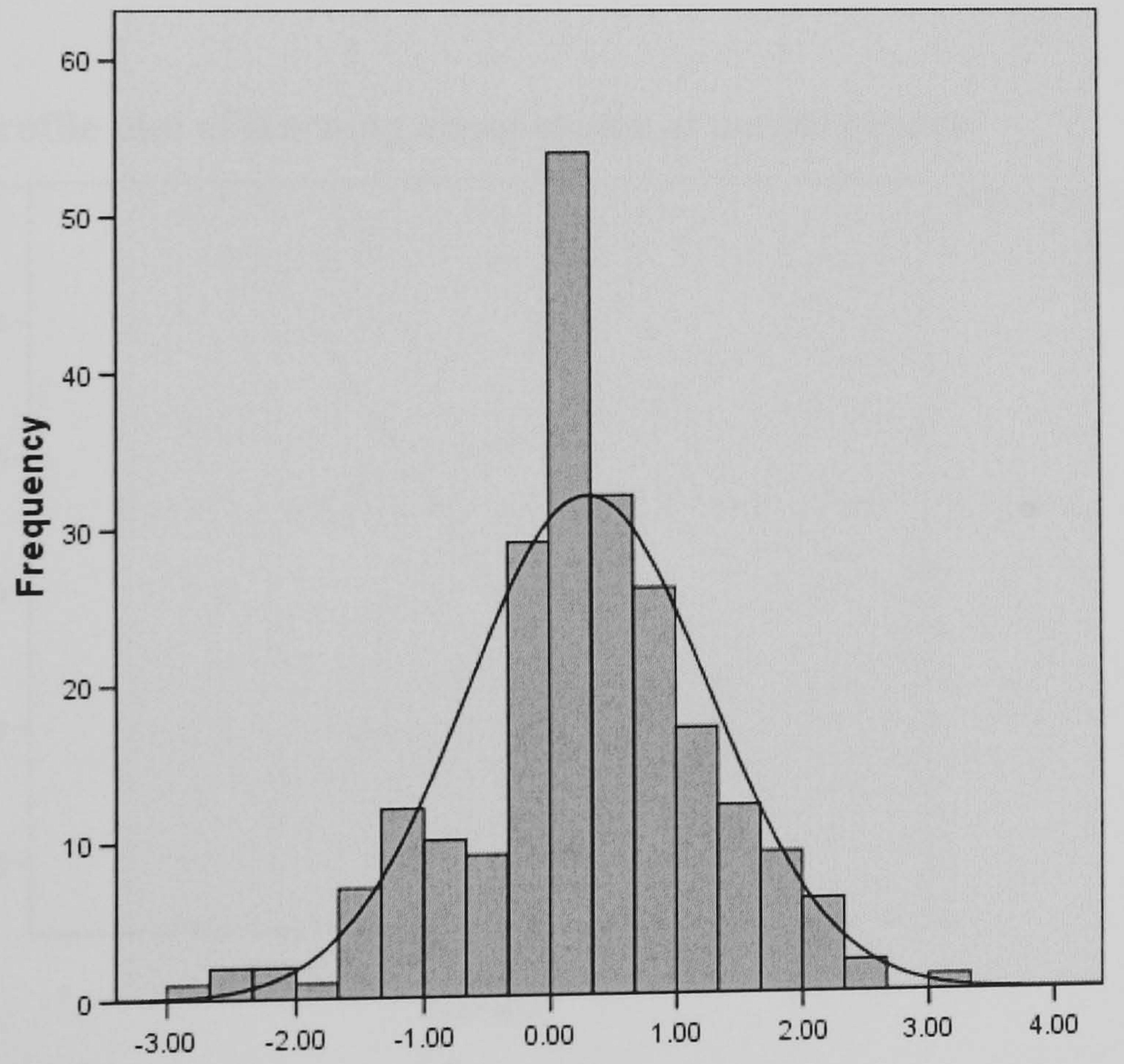
Figure 5.26 Profile plot of level of preparation across the universities



5.12 Learning about medicine

For the five items under this scale (*frustrating*, *depressing, boring, challenging* and *exciting*), a high score for the first three corresponds to negative experience whilst for the other two a high score would be positive. Before they were all combined into a single score, the scales for the first three were reversed. From the combined single score, pre-clinical LBC students had a lower mean score (0.30) than pre-clinical PBL students (0.31) on *learning about medicine*, the mean difference was not significant (t=-0.05, p=0.96). Looking at the five items (unreserved score) under *learning about medicine* individually, the pre-clinical PBL students rated three of the options (*frustrating*, *depressing* and *boring)* more highly than the LBC students rated them – the mean values from the PBL students were 0.96, 0.78, and 0.86 respectively, whilst the corresponding values for the LBC students were 0.16, 0.28 and 0.23 respectively. A significant difference was observed between the mean p-values of less than 0.05. The pre-clinical LBC students rated *challenging* (mean=0.11) and *exciting* (mean=0.02) higher than the pre-clinical PBL students: for the pre-clinical PBL students, the mean value for *challenging* was -1.06 and for *exciting* was -0.98. Thus results show that overall, pre-clinical LBC students have a more positive attitude towards *learning about medicine* than pre-clinical PBL students. However, the result is not significant. A histogram of *learning about medicine* is shown in figure 5.27.

Figure 5.27 Learning about medicine for pre-clinical students



GLM univariate analysis on *learning about medicine* indicates that the main factors of gender and university have significant results, with p-values of 0.01 and 0.03 respectively. The main factor of teaching method was not significant, having a p-value of 0.22. The profile plot in figure 5.28 indicates that female students achieved a higher score with LBC than male students, while male students achieved a higher score with

PBL than female students this difference between genders is more noticeable with LBC than PBL. The profile plot across the universities (figure 5.29) indicates that students in Universities A and B achieved a slightly higher score when using the LBC method rather than the PBL method, whilst students in Universities C and D achieved higher scores with the PBL method rather than the LBC method; this difference is more noticeable for University C. The two-way interaction between gender and teaching method was significant, having a p-value of 0.001, while that between university and teaching method was not significant (p-value of 0.33). The profile plot of learning about medicine across gender (figure 5.28) shows that female LBC students achieved a higher score than female PBL students, while male LBC students achieved a higher score than male PBL students. The difference due to teaching method is more noticeable for male students than for female students; this may be because female students are more willing to learn about medicine irrespective of the method of teaching employed. This may in turn be influenced by the female students' maternal instinct.

Figure 5.28 Profile plot of learning about medicine across gender

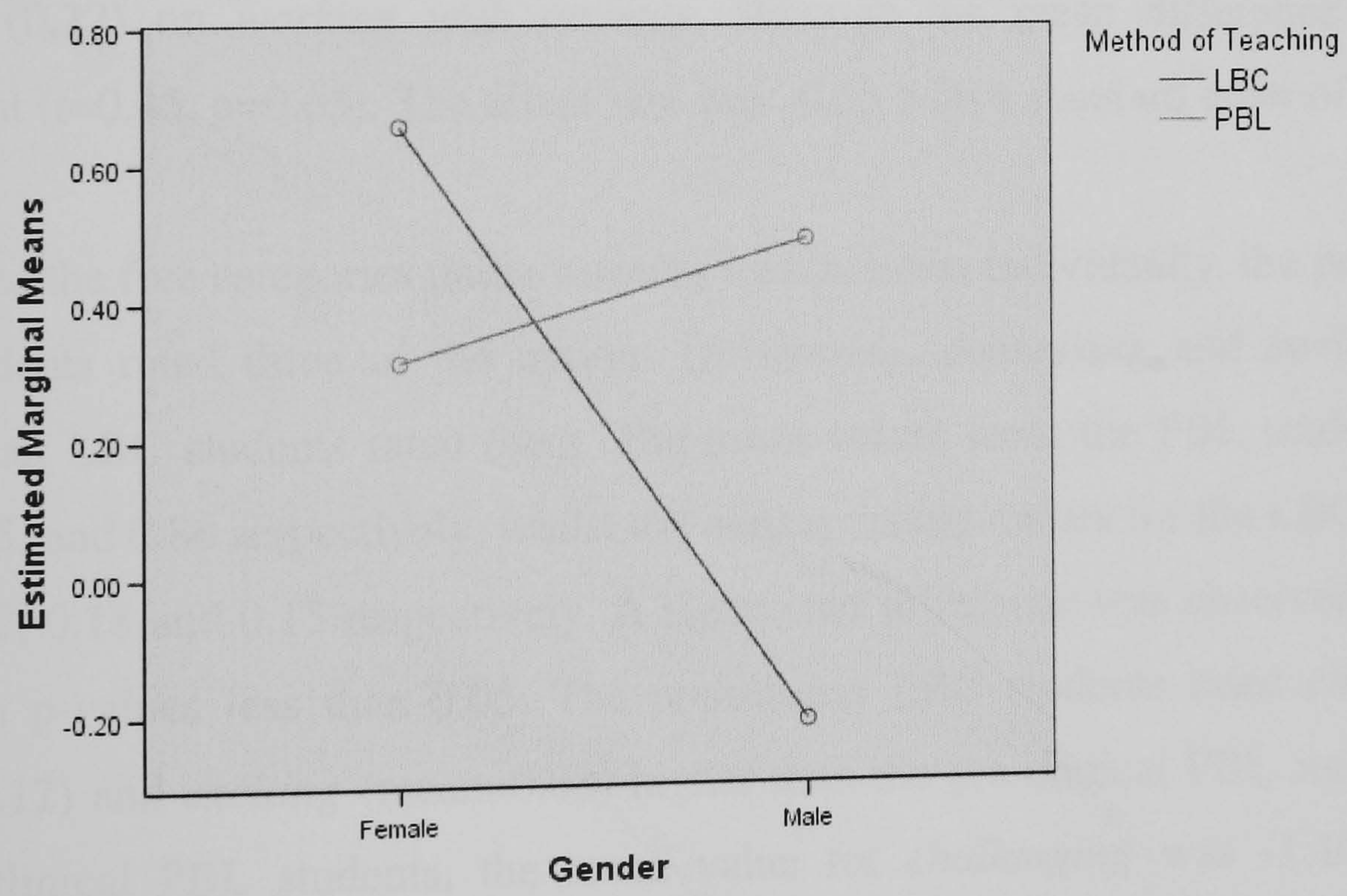
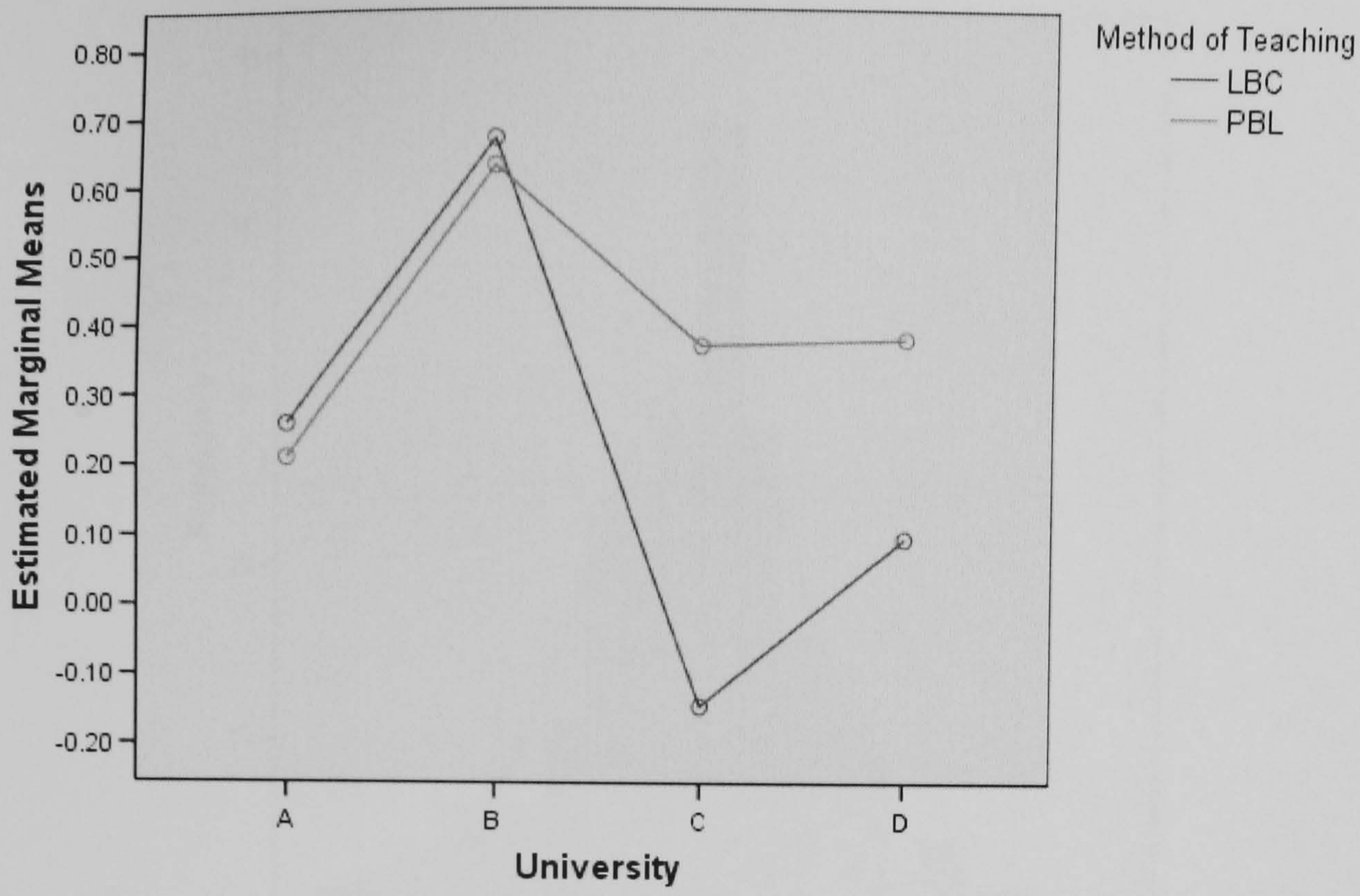


Figure 5.29 Profile plot of learning about medicine across the universities

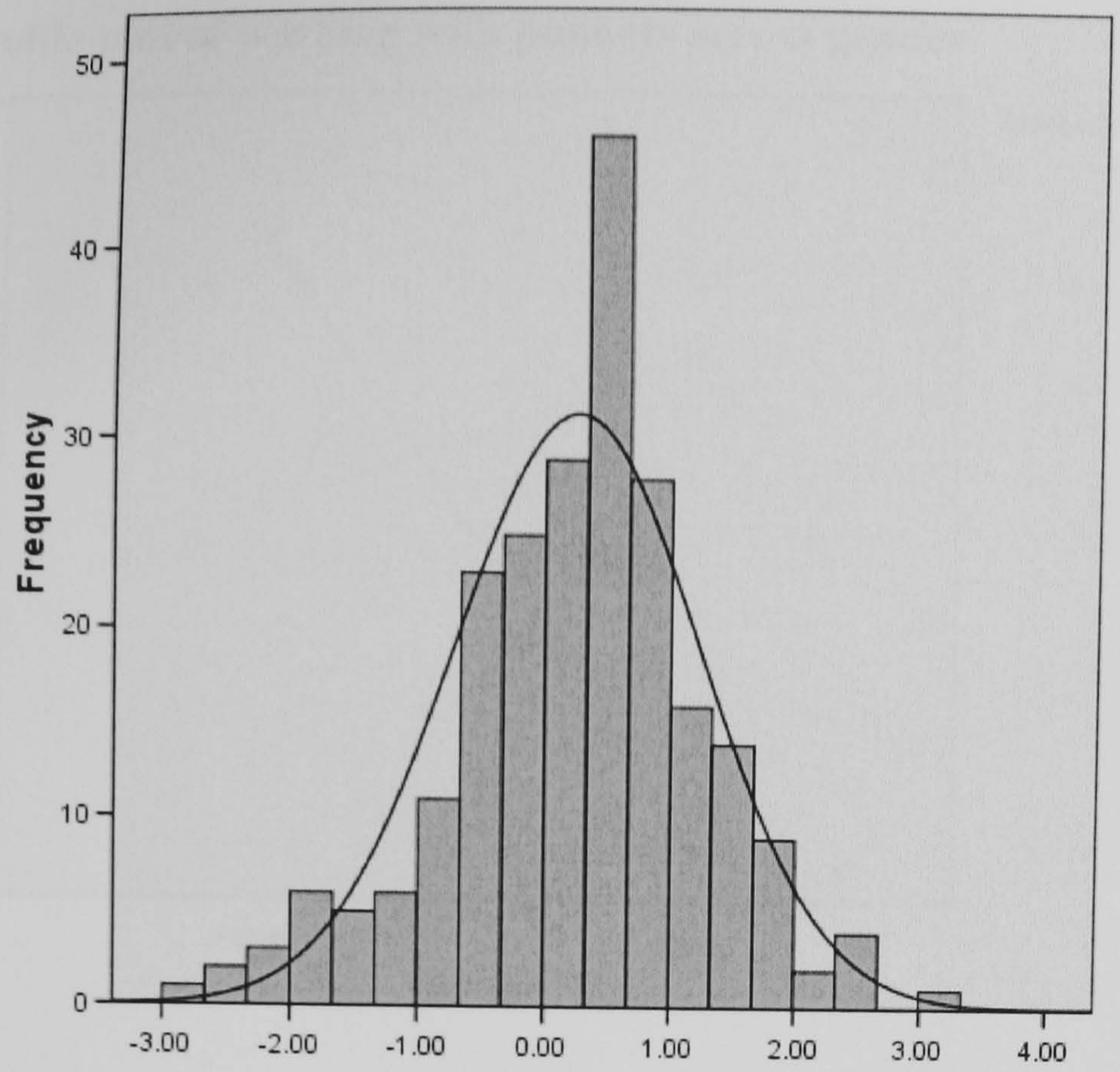


5.13 Working with patients

Pre-clinical LBC students had a higher mean score (0.28) than pre-clinical PBL students (0.22) on *working with patients*, although the mean difference was not significant (t=0.45, p=0.65). The effect size was -0.06 with a standard error of 0.13.

Looking at the five categories under *working with patients* individually, the pre-clinical PBL students rated three of the options (*frustrating*, *depressing* and *boring)* more highly than LBC students rated them. The mean values from the PBL students were 0.77, 0.85, and 0.86 respectively, whilst the corresponding values for the LBC students were 0.22, 0.18 and 0.15 respectively. A significant difference was observed between the mean p-values less than 0.05. The pre-clinical LBC students rated *challenging* (mean=0.12) and *exciting* (mean=0.08) higher than the pre-clinical PBL students: for the pre-clinical PBL students, the mean value for *challenging* was -1.10 and for *exciting* it was -1.03. Overall, pre-clinical LBC students have a more positive attitude towards *working with patients* than pre-clinical PBL students; however, the result is not significant. A histogram of *working with patients* is shown in figure 5.30.

Figure 5.30 Working with patients for pre-clinical students



GLM univariate analysis on *working with patients* indicates that the main factors of gender and university have significant results, with p-values of 0.02 and 0.01 respectively. The main factor of teaching method was not significant, with a p-value of 0.29. The profile plot in figure 5.31 indicates that in LBC, female students achieved a higher score than male students, whilst in PBL, male students achieved a higher score than female students, the difference being most noticeable in the case of LBC. The profile plot across the universities (figure 5.32) indicates that students in Universities A and B achieved a slightly higher score when using the LBC method than the PBL method, whilst students in Universities C and D achieved a higher score with the PBL method than the LBC method. This difference is most noticeable for University C. The two-way interaction between gender and teaching method was significant, having a p-value of 0.01, while that between university and teaching method was not significant (p-value of 0.12). The profile plot of working with patients across gender shows that female LBC students achieved a higher score than female PBL students, while male LBC students achieved a higher score than male PBL students. The difference due to teaching method is more noticeable for male students than for female students, which may be because female students are more willing to work with patients irrespective of the method of teaching employed. This may in turn be influenced by the female students' maternal instinct.

Figure 5.31 Profile plot of working with patients across gender

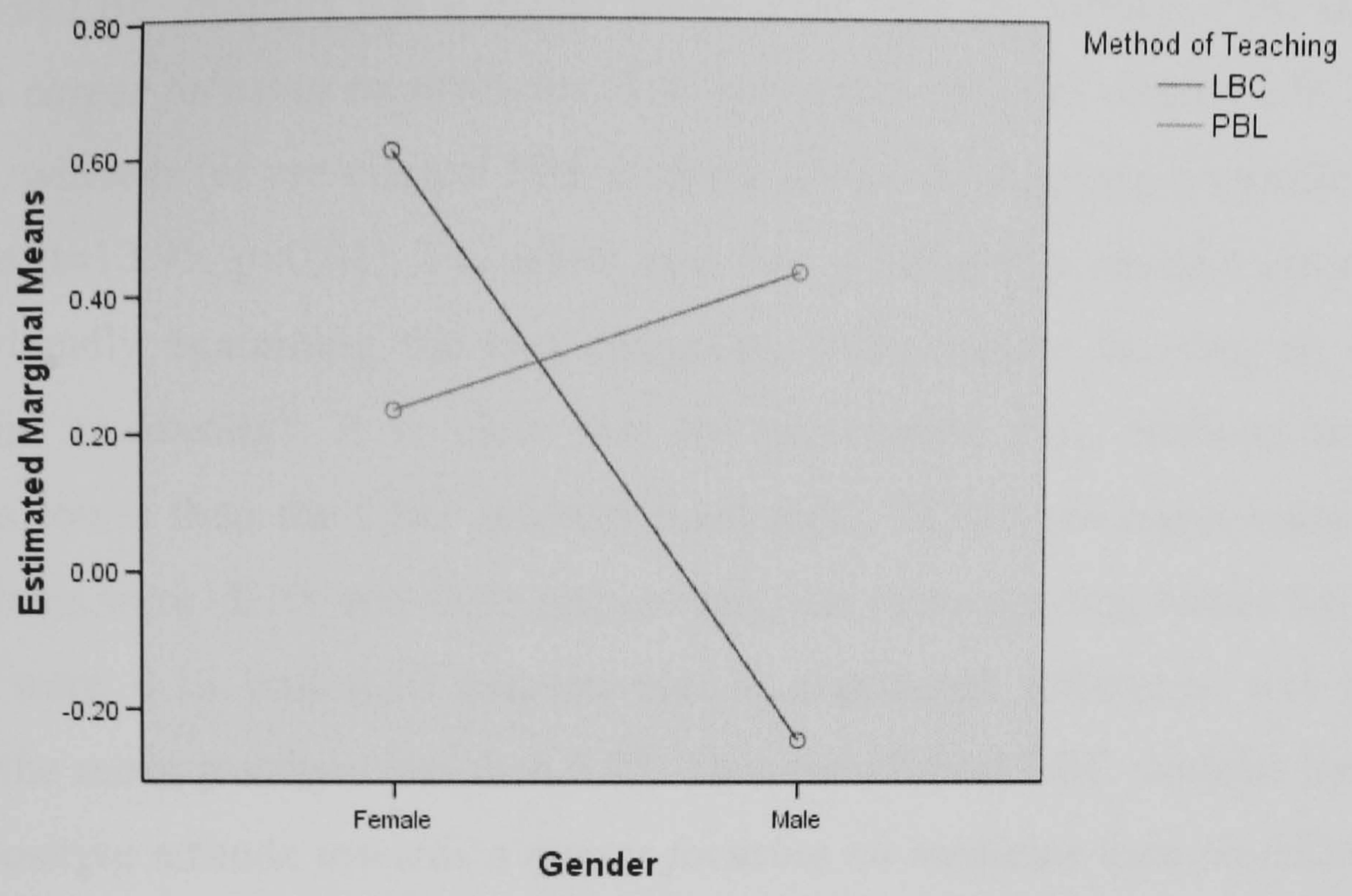
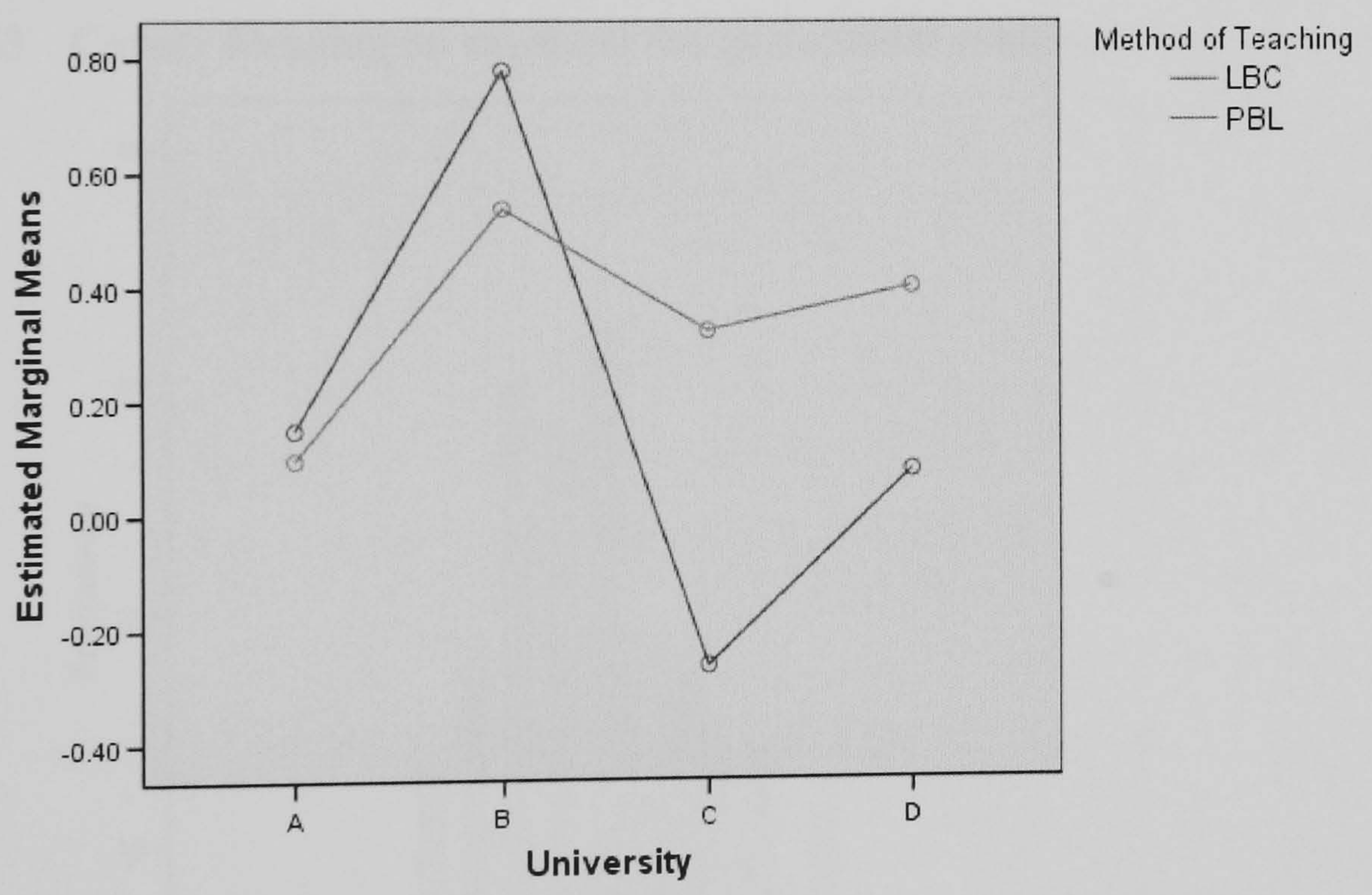


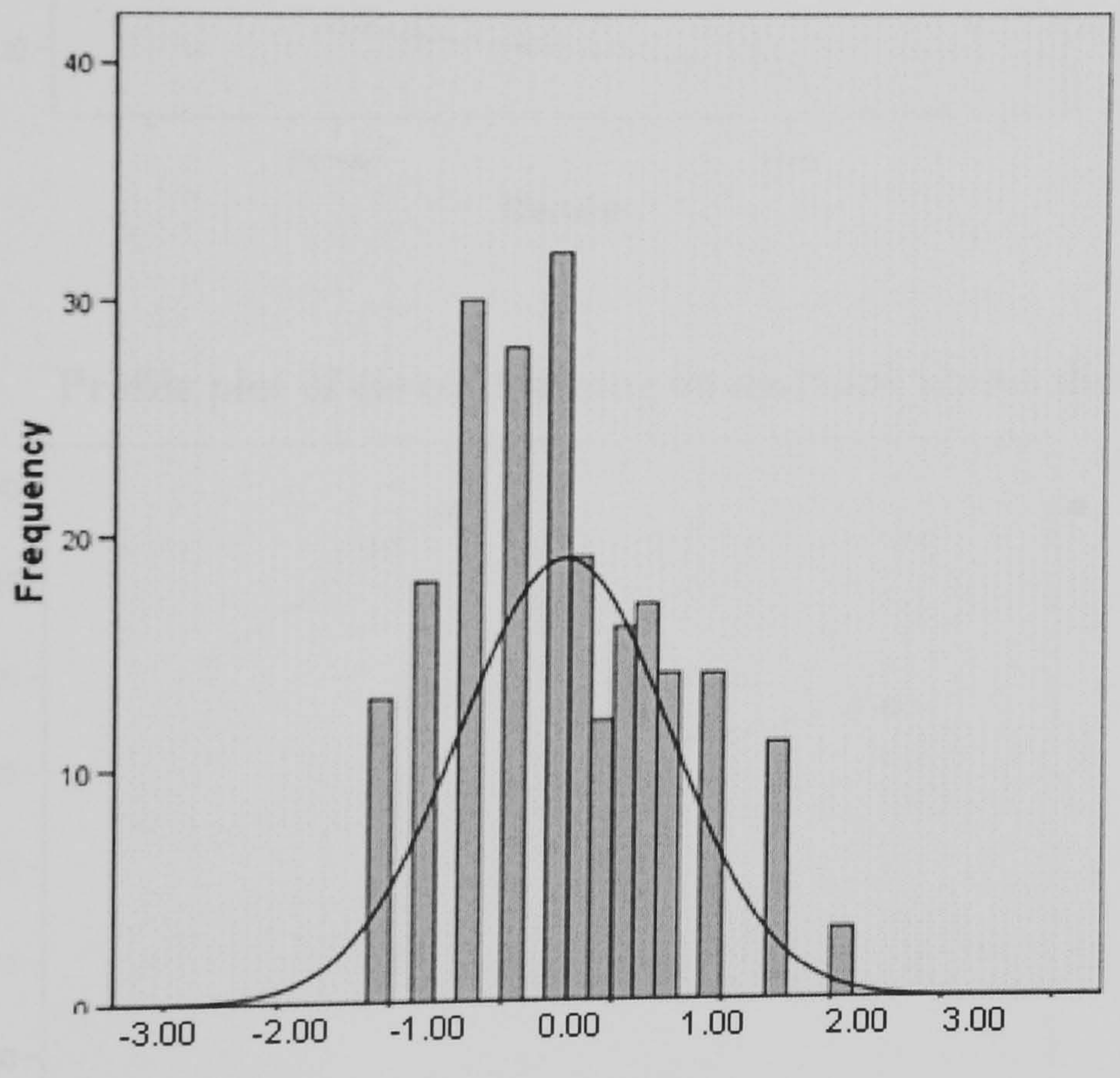
Figure 5.32 Profile plot of working with patients across the universities



5.14 Career focusing on medicine

Pre-clinical LBC students had a higher mean score than pre-clinical PBL students as regards a *career focusing on medicine*. The mean score for pre clinical LBC students was 0.13, whereas for pre-clinical PBL students it was -1.18, giving a significant mean difference (t=13.95, p=0.01). The effect size was -1.92 with a standard error of 0.16. On individually examining the two categories under *career focusing on medicine* (*likely* and *rewarding*), it is clear that the pre-clinical PBL students rated both categories lower than the LBC students rated them. Whilst the mean values for the PBL students were -1.10, and -0.99 respectively, the corresponding values for the LBC students were 0.13 and 0.10 respectively. A significant difference was observed between the mean p-values less than 0.05. Thus pre-clinical LBC students had overall a more positive attitude towards a *career focusing on medicine* than pre-clinical PBL students. A histogram of *career focusing on medicine* is shown below in figure 5.33.

Figure 5.33 Career focusing on medicine for pre-clinical students



GLM univariate analysis on *career focusing on medicine* indicates that the main factors of gender and teaching method have significant results, with p-values of 0.04 and 0.01 respectively. The main factor of university was not significant, having a p-value of 0.21. The profile plot in figure 5.34 indicates that female students achieved a higher score than male students on both the LBC and PBL methods; this difference was more noticeable for LBC than PBL, however. The profile plot across the universities (figure 5.35) indicates that students in all four universities achieved a higher score when using the LBC method rather than the PBL method. The two-way interactions between gender and teaching method and between university and teaching method were not significant, having p-values of 0.24 and 0.08 respectively.

Figure 5.34 Profile plot of career focusing on medicine across gender

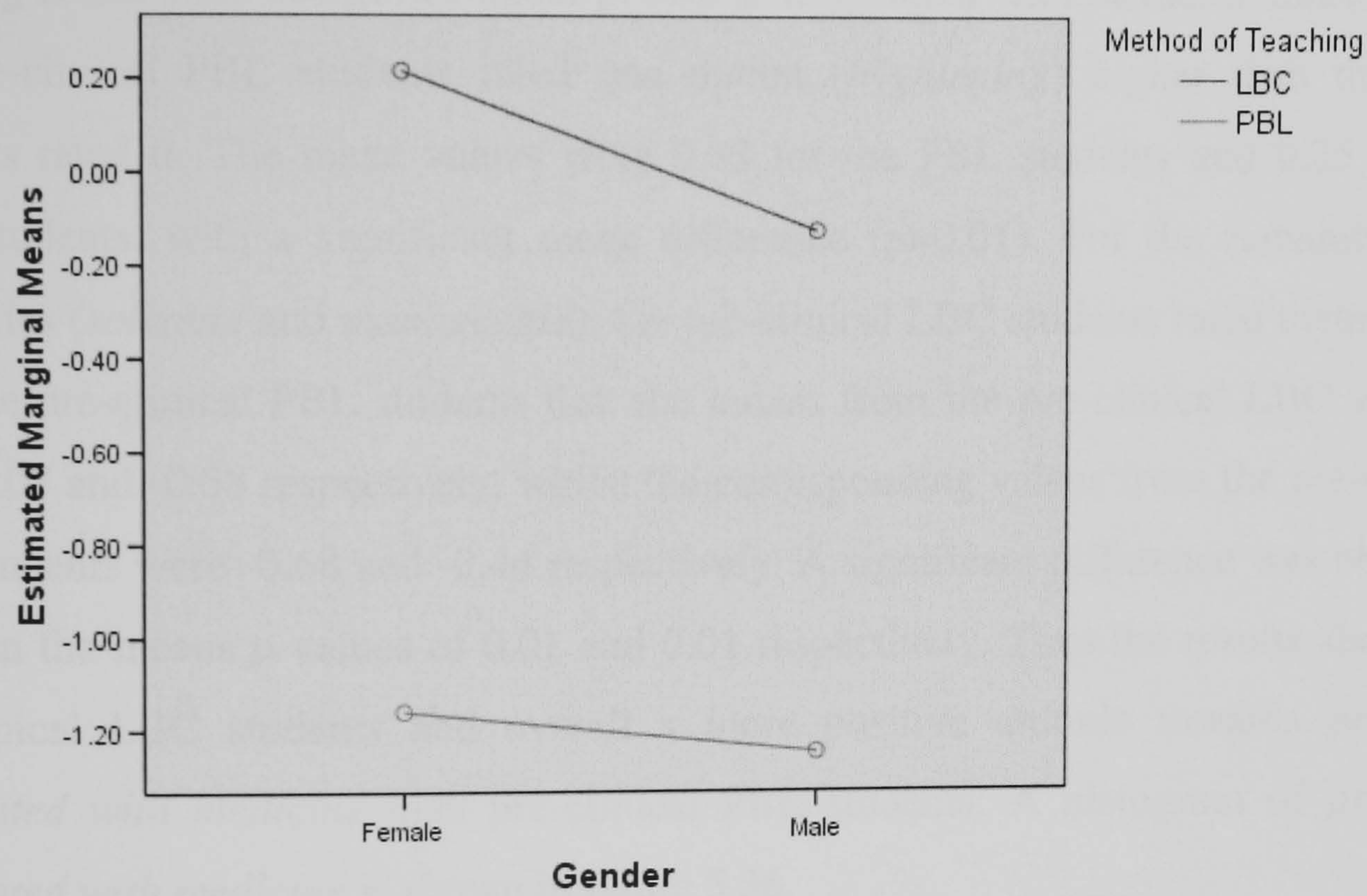
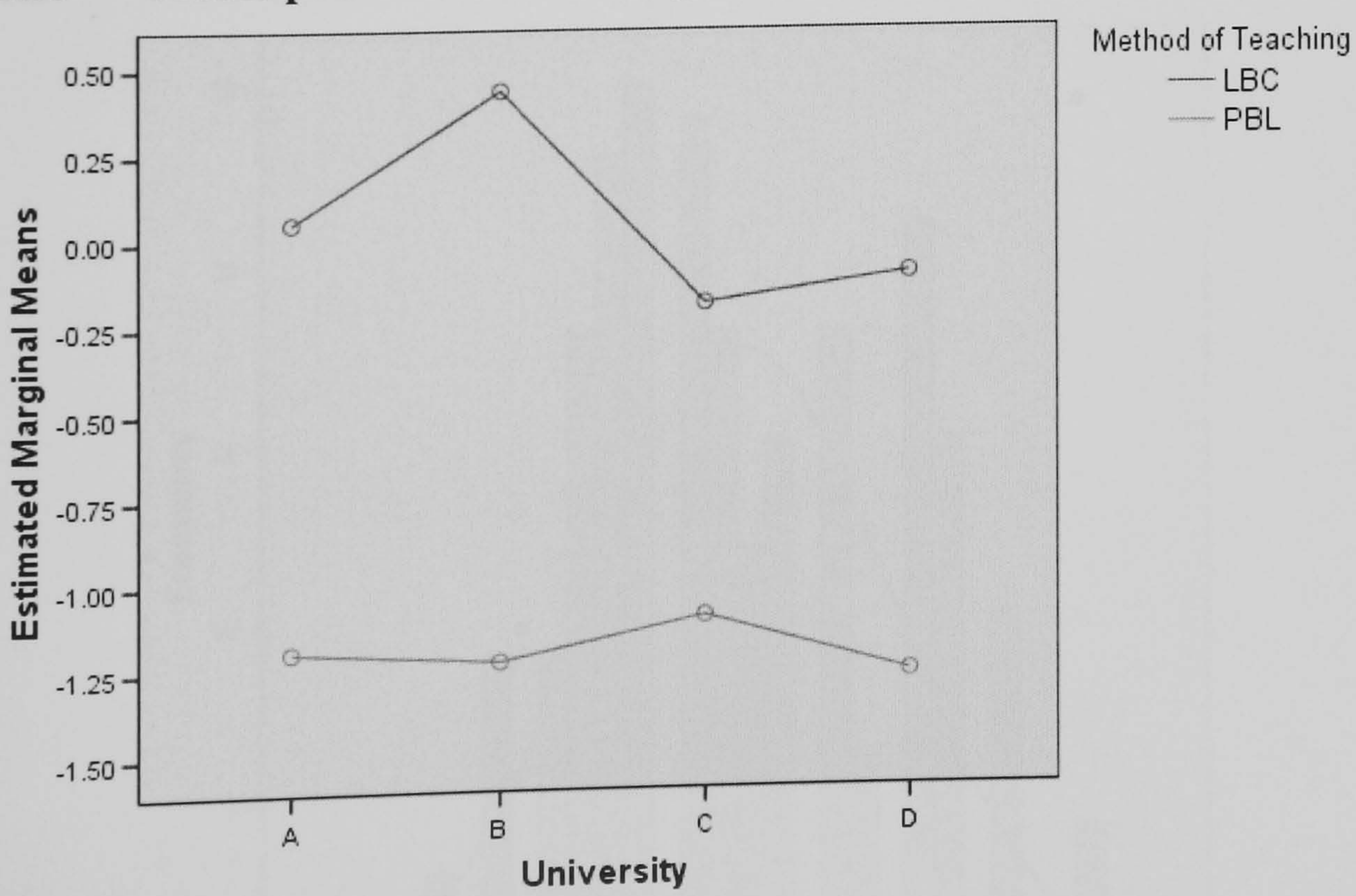


Figure 5.35 Profile plot of career focusing on medicine across the universities

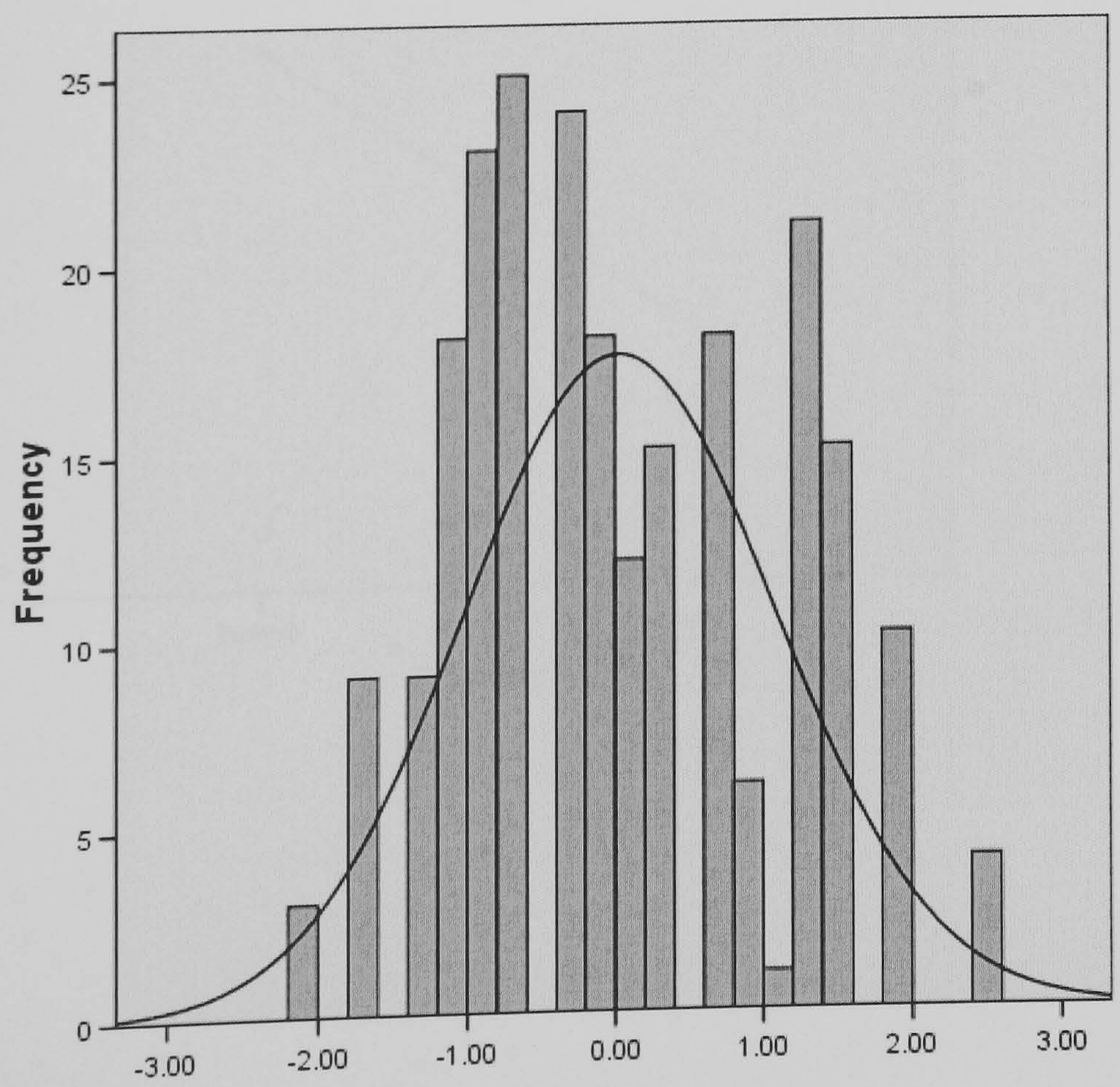


5.15 Problems associated with medicine

Pre-clinical LBC students had a higher mean score than pre-clinical PBL students on *problems associated with medicine*. The mean score for pre-clinical LBC students was 0.15, whereas for pre-clinical PBL students it was -0.14. The mean difference was significant (t=2.08, p=0.04), and the effect size was -0.28 with a standard error of 0.13.

Looking at the three categories under *problems associated with medicine* individually, the pre-clinical PBL students rated one option (*frightening*) higher than the LBC students rated it. The mean values were 0.83 for the PBL students and 0.25 for the LBC students, with a significant mean difference (p=0.01). For the remaining two categories (*solvable* and *manageable*), the pre-clinical LBC students rated them higher than the pre-clinical PBL students did: the means from the pre-clinical LBC students were 0.07 and -0.08 respectively, whilst the corresponding values from the pre-clinical PBL students were -0.68 and -0.44 respectively. A significant difference was observed between the means p-values of 0.01 and 0.01 respectively. Thus the results show that pre-clinical LBC students had overall a more positive attitude towards *problems associated with medicine* than pre-clinical PBL students. A histogram of *problems associated with medicine* is shown in figure 5.36.

Figure 5.36 Problems associated with medicine for pre-clinical students



GLM univariate analysis on *problems associated with medicine* indicates that the main factor of gender was significant, having a p-value of 0.001. The main factors of teaching method and university, on the other hand were not significant, having p-values of 0.89 and 0.13 respectively. The profile plot in figure 5.37 indicates that female students using the PBL method achieved a lower score than male students. Therefore, female PBL students are more positive towards *problems associated with medicine* than male PBL students. In the LBC groups, however, female students achieved a higher score than male students, indicating therefore that female LBC students are more negative towards *problems associated with medicine* than male LBC students. Yet the profile plot across universities (figure 5.38) indicates that there is no clear pattern across all four universities. The two-way interaction between gender and teaching method was significant, having a p-value of 0.00, whereas the two-way interaction between university and teaching method was not significant, having a p-value of 0.17.

Figure 5.37 Profile plot of problems associated with medicine across gender

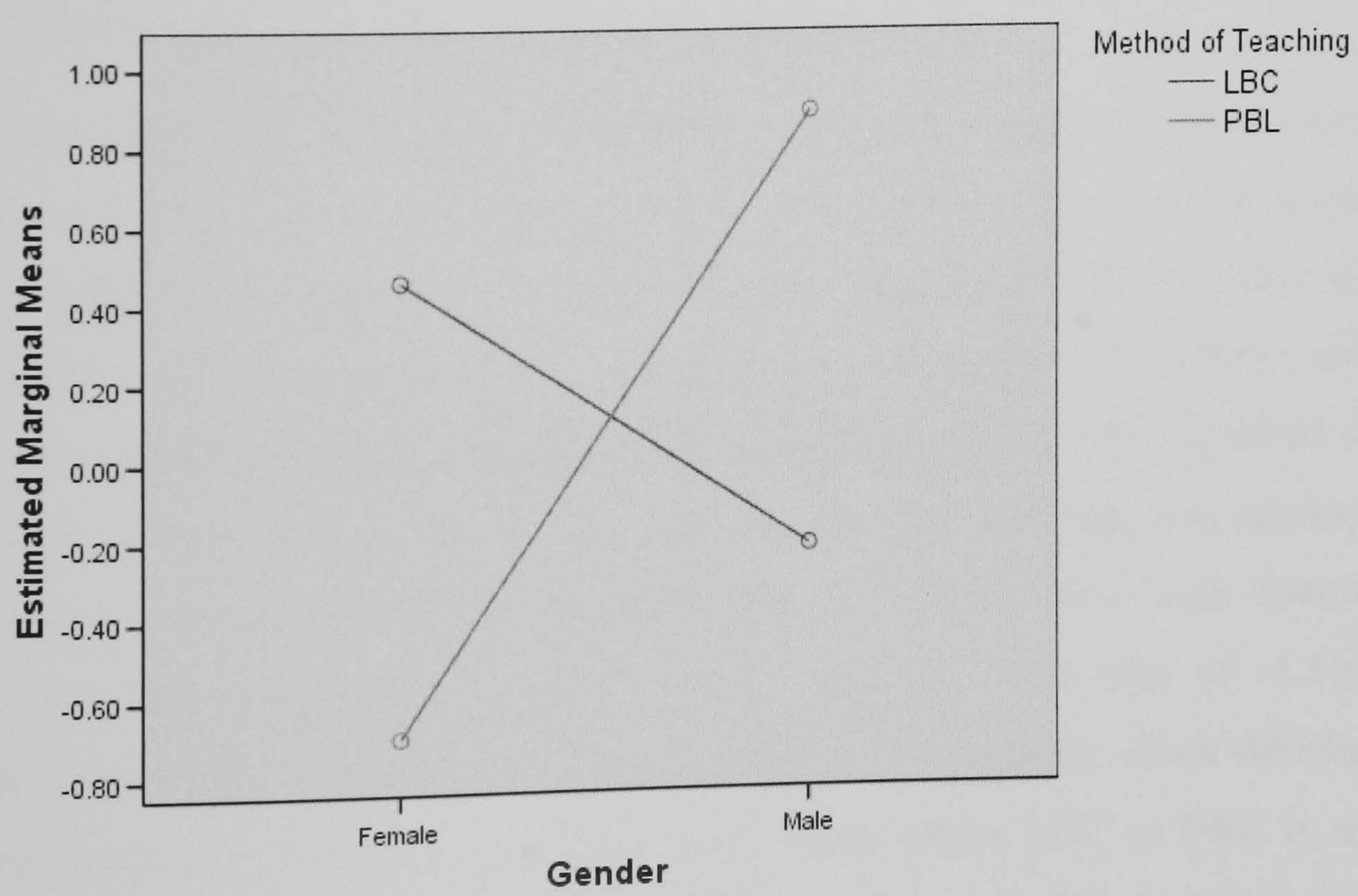
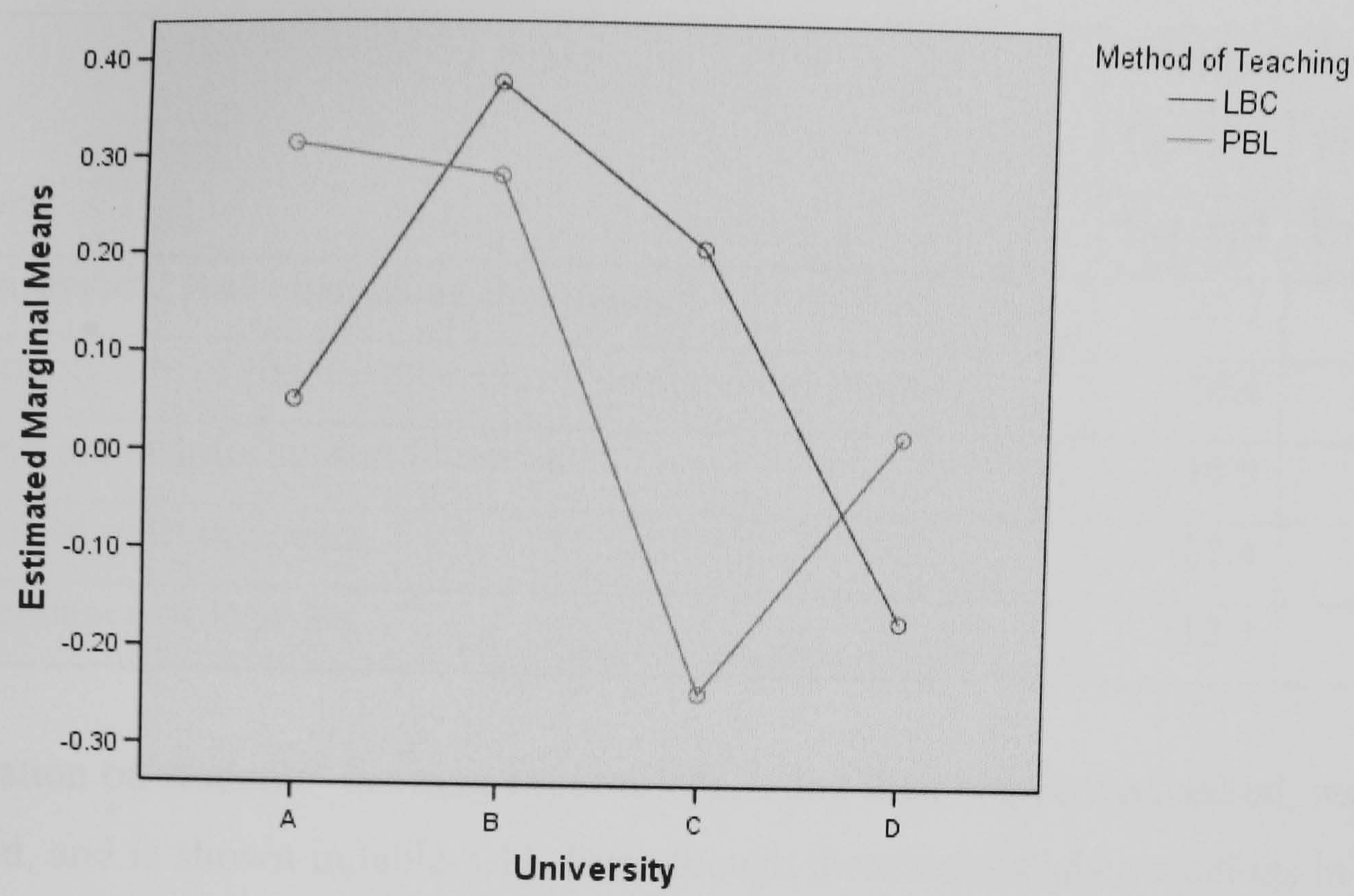


Figure 5.38 Profile plot of problems associated with medicine across the universities



5.16 Course evaluation form (CEF)

5.16.1 HGU Evaluation, unit format and amount of work

Information regarding how pre clinical students studied human genetics units (HGU) was gathered from the course evaluation form. Nearly 50% of pre-clinical students said they studied HGU through LBC methods and the remaining 50% said they studied it through PBL. The students were also asked what percentage of the entire course they thought should use their specified methods. Whilst pre-clinical LBC students said that they would prefer 50% of their education to use this method, the corresponding percentage for pre-clinical PBL students was just 28%. This was found to be significantly different, with a p-value of 0.01, and an effect size of -1.19 with a standard error of 0.14. The main factors considered by students when deciding what percentage of their education should be taught using either LBC or PBL is shown in table 5.10, below. According to pre-clinical PBL students, *the enjoyment of the method* was the most important factor considered (31.6%) followed by the *volume of information* they received (21.1%). For pre-clinical LBC students, the key factor was the *importance to their professional practice* (26.6%), followed by *the enjoyment* they got from the method (22.7%).

Table 5.10 Main factors considered

Factors	Method of Teaching	
	LBC	PBL
	Percent	Percent
The enjoyment that I had using this method	22.7	31.6
The importance of this method to my professional practice	26.6	16.4
The volume of information I learned	16.9	21.1
Interaction with my peers	21.4	18.8
Independence of learning	12.3	11.8

Information on students' learning expectations, using their respective method, was also solicited, and is shown in table 5.11. Even though there were slight variations in terms of percentages, no significant association was observed between teaching method (LBC or PBL) and learning expectations. The Pearson Chi-Squared statistic was 2.82 with a p-value of 0.59.

Table 5.11 Learning expectations of pre-clinical students

			During the past three class sessions, I learned:					
			A lot more than I expected	Somewhat more than I expected	About as much as I expected	Somewhat less than I expected	Much less than I expected	Total
What method did you use to study Human Genetics Units?	LBC	Count	25	38	19	26	6	114
		% within What method did you use to study Human Genetics Units?	21.9%	33.3%	16.7%	22.8%	5.3%	100.0%
	PBL	Count	24	33	27	20	8	112
		% within What method did you use to study Human Genetics Units?	21.4%	29.5%	24.1%	17.9%	7.1%	100.0%
Total		Count	49	71	46	46	14	226
		% within What method did you use to study Human Genetics Units?	21.7%	31.4%	20.4%	20.4%	6.2%	100.0%

ChiSq=2.82, df=4, p=0.59

Concerning the format used in classes, 39% of the pre-clinical LBC students said they would like to experience the same format again, whilst the corresponding percentage for pre-clinical PBL students was 36%. Although 17% of the pre-clinical LBC students would prefer not to experience LBC again, a higher percentage (26%) of the pre-clinical PBL students would prefer not to experience the PBL format again. Even though there are variations in these percentages, no significant association was observed; the Pearson Chi-Squared statistic was 2.53 with a p-value of 0.47 (see table 5.12).

Table 5.12 Format used in classes

			The format used in the past three classes is one that I would:				
			Like to experience again	Like to experience again if these minor changes were made	Like to experience again if major changes were made:	Prefer not to experience again	Total
Method of Teaching	LBC	Count	42	27	20	18	107
		% within Method of Teaching	39.3%	25.2%	18.7%	16.8%	100.0%
	PBL	Count	35	20	18	25	98
		% within Method of Teaching	35.7%	20.4%	18.4%	25.5%	100.0%
Total		Count	77	47	38	43	205
		% within Method of Teaching	37.6%	22.9%	18.5%	21.0%	100.0%

ChiSq=2.53, df=3, p=0.47

Concerning the amount of work undertaken, 39% (a very high figure) of the pre-clinical LBC students said it was more than what they were used to and intolerable, whilst the corresponding percentage for pre-clinical PBL students was only 24%. For 16% of the pre-clinical LBC students, the amount of work was more than what they were used to but tolerable, and the corresponding percentage for the pre-clinical PBL students was approximately 25%. It is worth noting that 35% of the pre-clinical PBL students said that the amount of work was not as much as they were used to, whilst the corresponding percentage for the pre-clinical LBC students was half this at 18%. A significant association was therefore observed between the teaching method (LBC or PBL) and the amount of work; the Pearson Chi-Squared was 15.67, with a p-value of 0.001. Overall, pre-clinical LBC students were more likely than pre-clinical PBL students to find the workload higher than they were used to (see table 5.13 for details).

Table 5.13 Amount of work for pre-clinical students

			Compared to the work I have done for this class so far, the amount of work involved in the past three class sessions was:				
			More than I am used to and intolerable	More than I am use to but tolerable	About same as I am used to	Not as much as I am used to	Total
What method did you use to study Human Genetics Units?	LBC	Count	44	18	32	20	114
		% within What method did you use to study Human Genetics Units?	38.6%	15.8%	28.1%	17.5%	100%
	PBL	Count	27	28	19	39	113
		% within What method did you use to study Human Genetics Units?	23.9%	24.8%	16.8%	34.5%	100%
Total		Count	71	46	51	59	227
		% within What method did you use to study Human Genetics Units?	31.3%	20.3%	22.5%	26.0%	100%

ChiSq=15.67, df=3, p=0.001

5.16.2 Small-group experience

During the evaluation, students were divided into small groups and asked to undertake certain activities. They were later asked if they were aware of the activities of at least one of the other small groups; 38% of pre-clinical LBC students were aware of the activities of at least one other small group, whereas only 29% of the pre-clinical PBL students were aware of the activities of at least one other small group. There was no significant association between the teaching method (LBC or PBL) and the awareness of the activities of other small groups; the Pearson Chi-Squared was 1.85, with a p-value of 0.17. Overall, 33.5% (n=76) of the pre-clinical students were aware of the activities of at least one other small group (see table 5.14).

Table 5.14 Small-group experience

			Were you aware of the activities of at least one of the other small group?		Total
			No	Yes	
What method did you use to study Human Genetics Units?	LBC	Count	71	43	114
		% within What method did you use to study Human Genetics Units?	62.3%	37.7%	100.0%
	PBL	Count	80	33	113
		% within What method did you use to study Human Genetics Units?	70.8%	29.2%	100.0%
Total		Count	151	76	227
		% within What method did you use to study Human Genetics Units?	66.5%	33.5%	100.0%

ChiSq=1.85, df=1, p=0.17

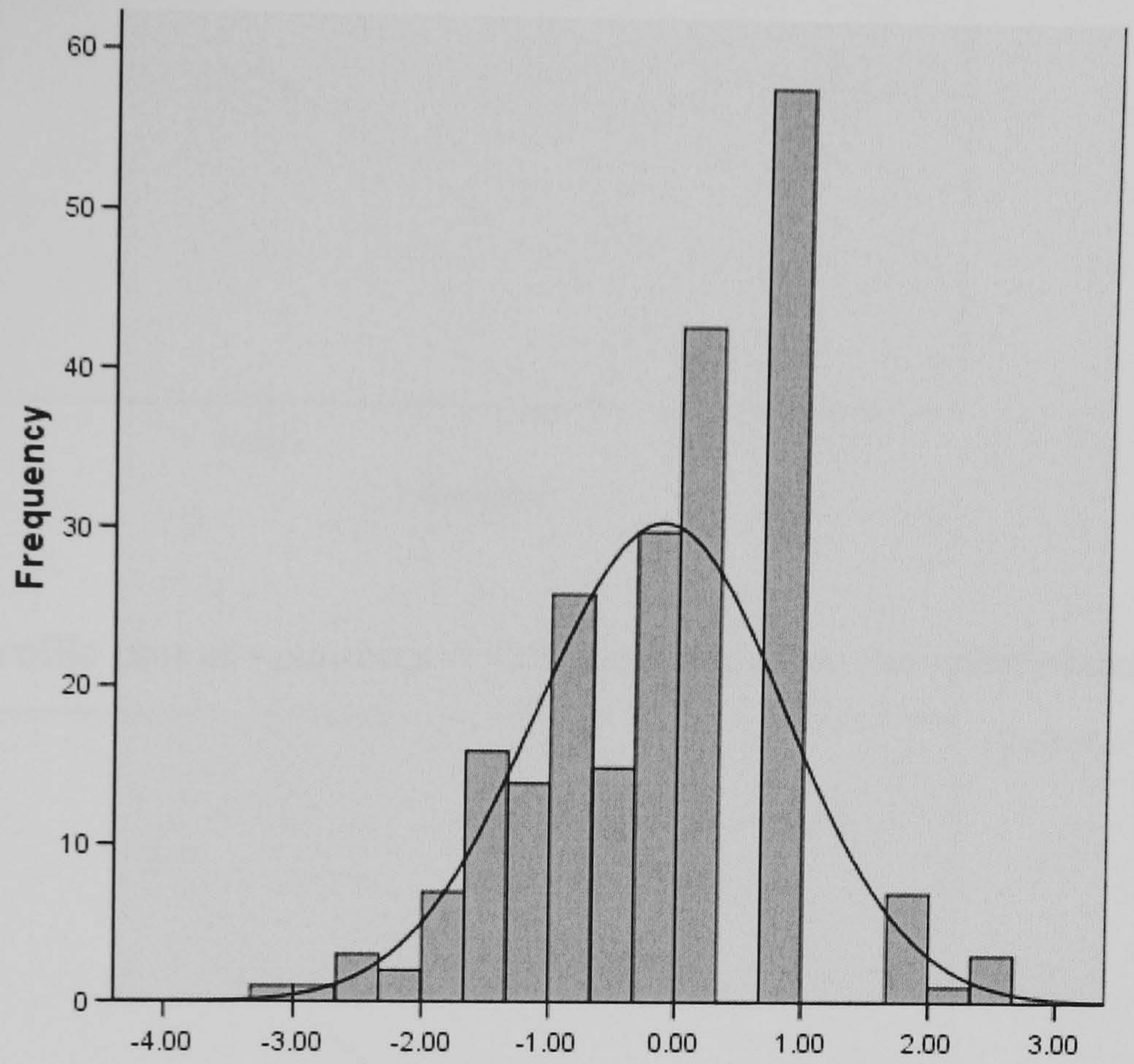
5.17 Resources of information

Pre-clinical LBC students had a higher mean score than pre-clinical PBL students on *resources of information.* The mean score from pre-clinical LBC students was -0.06, whereas that from pre-clinical PBL students was -0.22. The mean difference was not significant (t=1.19, p=0.24).

The eight categories under *resources of information* were: *lectures*, *tutorials*, *faculty outside class*, *other students outside class*, *textbooks*, *articles*, *labs* and *other.* Looking at the options individually, a significant result was obtained on only two of them, namely *lectures* and *tutorials.* Pre-clinical LBC students have a higher mean score than pre-clinical PBL students on *lectures.* The mean score from pre-clinical LBC students was 0.59, whereas that from pre-clinical PBL students was 0.07. The mean difference was significant, with a p-value of 0.01. The effect size was -0.57, with a standard error of 0.13.

For *tutorials*, pre-clinical LBC students had a lower mean score (-0.54) than pre-clinical PBL students (-0.19). The mean difference was significant, having a p-value of 0.01; the effect size was 0.39, with a standard error of 0.13. These results indicate that for pre-clinical LBC students most of their knowledge came from *lectures* rather than *tutorials*, while for pre-clinical PBL students the reverse was true. A histogram of *resources of information* is shown in figure 5.39. Overall, no significant result was observed between pre-clinical LBC and PBL students with regards *resources of information.*

Figure 5.39 Resources of information for pre-clinical students



GLM univariate analysis on *resources of information* indicates that the main factor of university did have a significant result, with a p-value of 0.001. The main factors of gender and teaching method were not significant, with p-values of 0.88 and 0.13 respectively. The profile plot in figure 5.40 indicates that male students achieved a higher score than female students in the LBC group, whilst this pattern is reversed for PBL, where female students achieved a higher score than male students. The profile plot across the universities (figure 5.41) indicates that there was no clear pattern across all four universities, though students in the LBC groups at Universities B and D achieved higher scores than those using PBL methods. The two-way interactions between gender and teaching method and between university and teaching method were not found to be significant, having p-values of 0.19 and 0.34 respectively.

Figure 5.40 Profile plot of resources of information across gender

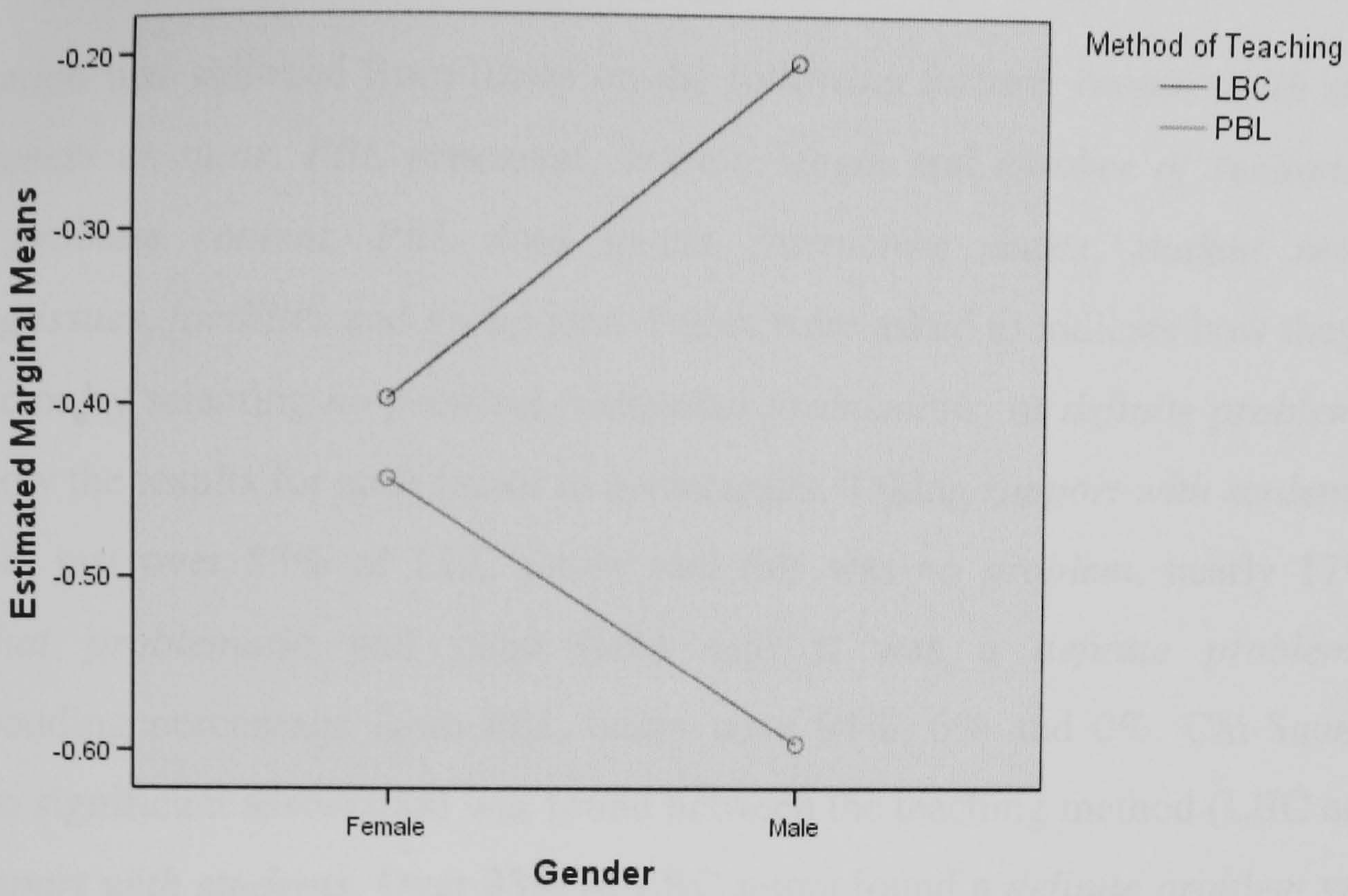
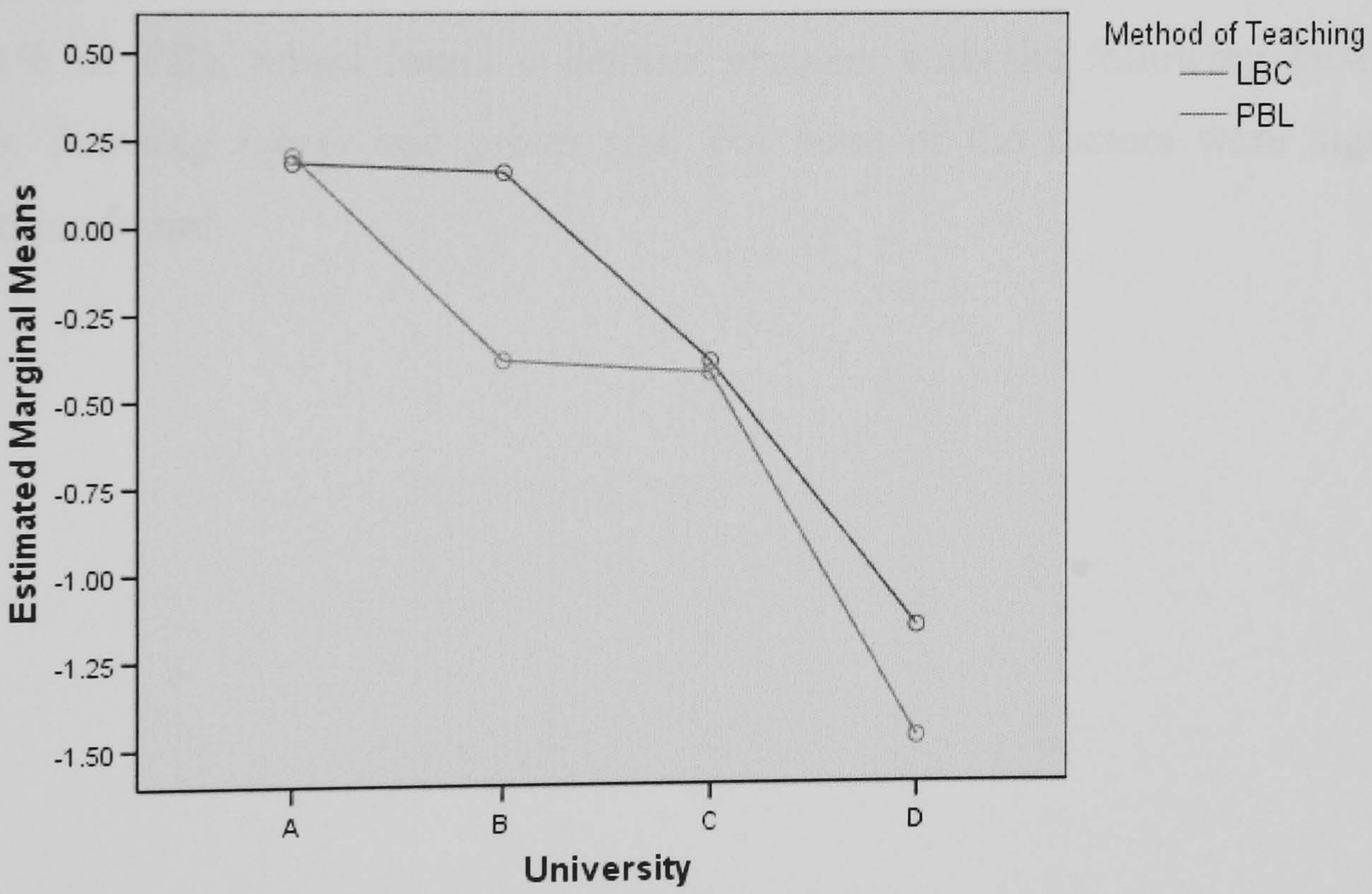


Figure 5.41 Profile plot of resources of information across the universities



5.18 PBL and LBC tutors' views

Information was solicited from tutors on the following factors: *rapport with students*, *effectiveness as tutor*, *PBL processes*, *session length* and *number of sessions*, *topic order*, *problem content*, *PBL data sheets*, *instruction sheets*, *student resources*, *learning issues*, *facilities* and *group size*. Tutors were asked to indicate how they found each factor by selecting *no problem*, *somewhat problematic*, or *definite problem*; table 5.15 show the results for each factor in percentages. Taking *rapport with students* as an example, just over 83% of LBC tutors said this was *no problem*, nearly 17% said *somewhat problematic* and none (0%) said it was a *definite problem*. The corresponding percentage from PBL tutors were 94%, 6% and 0%. Chi-Square test show no significant association was found between the teaching method (LBC or PBL) and *rapport with students*. Over 33% of LBC tutors found a *definite problem* with the following factors: *student resources*, *learning issues*, *facilities* and *group size*. Twenty-five percent of PBL tutors found a *definite problem* with *student resources* and just over 31% of PBL tutors found a *definite problem* with the following factors: *no. sessions*, *learning issues* and *group size*. For none of the factors were significant associations found.

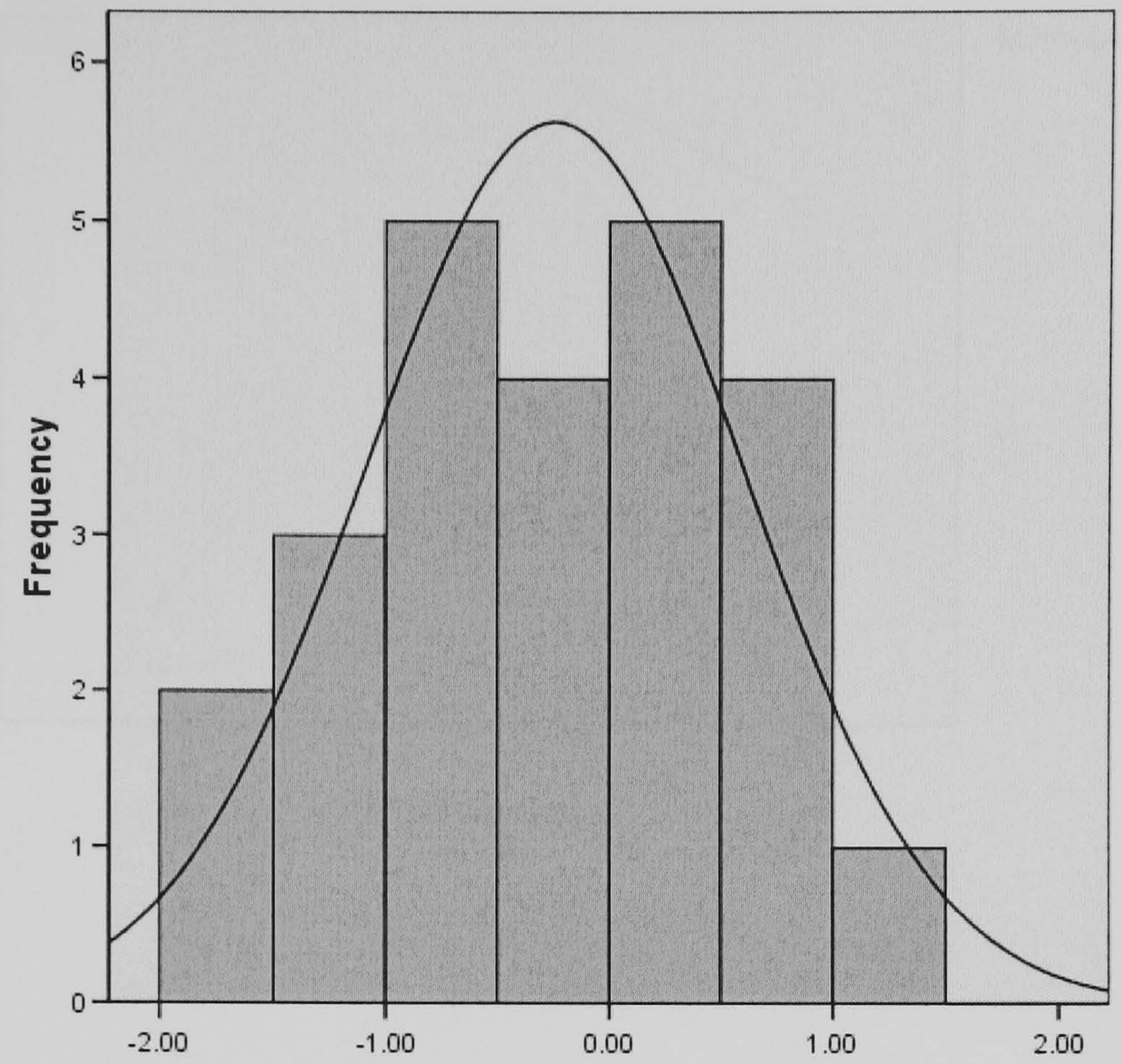
Table 5.15 LBC and PBL tutors' perception of learning method (n=17)

Factor	LBC			PBL		
	No Problem	Somewhat Problematic	Definite Problem	No Problem	Somewhat Problematic	Definite Problem
Rapport with students	83.3	16.7	0.0	93.8	6.3	0.0
Effectiveness as tutor	83.3	16.7	0.0	93.8	6.3	0.0
PBL process	50.0	50.0	0.0	68.7	31.3	0.0
Session length	66.7	16.7	16.7	71.4	28.6	0.0
No. sessions	66.7	16.7	16.7	50.0	18.8	31.3
Topic order	100.0	0.0	0.0	40.0	33.3	26.7
Problem content	66.7	33.3	0.0	37.5	37.5	25.0
PBL data sheets	50.0	33.3	16.7	40.0	40.0	20.0
Instruction sheets	83.3	16.7	0.0	38.5	46.2	15.4
Student resources	33.3	33.3	33.3	25.0	50.0	25.0
Learning issues	33.3	33.3	33.3	31.3	37.5	31.3
Facilities	50.0	16.7	33.3	43.8	37.5	18.8
Group Size	50.0	16.7	33.3	43.8	25.0	31.3

5.19 Tutors' perception of learning method

Pre-clinical LBC tutors had a higher mean score than pre-clinical PBL tutors on *tutors' perception of learning method*. The mean score from pre-clinical LBC tutors was 0.32, whereas that from pre-clinical PBL tutors was -0.43. The mean difference was not significant (t=2.01, p=0.06), and the effect size was -0.86, with a standard error of 0.49. Of the fourteen categories under *tutors' perception of learning method,* clinical LBC tutors achieved higher scores than pre-clinical PBL tutors on eleven. Overall, however, the perception of tutors did not vary significantly from LBC to PBL. A histogram of *tutors' perception of learning method* is shown in figure 5.42.

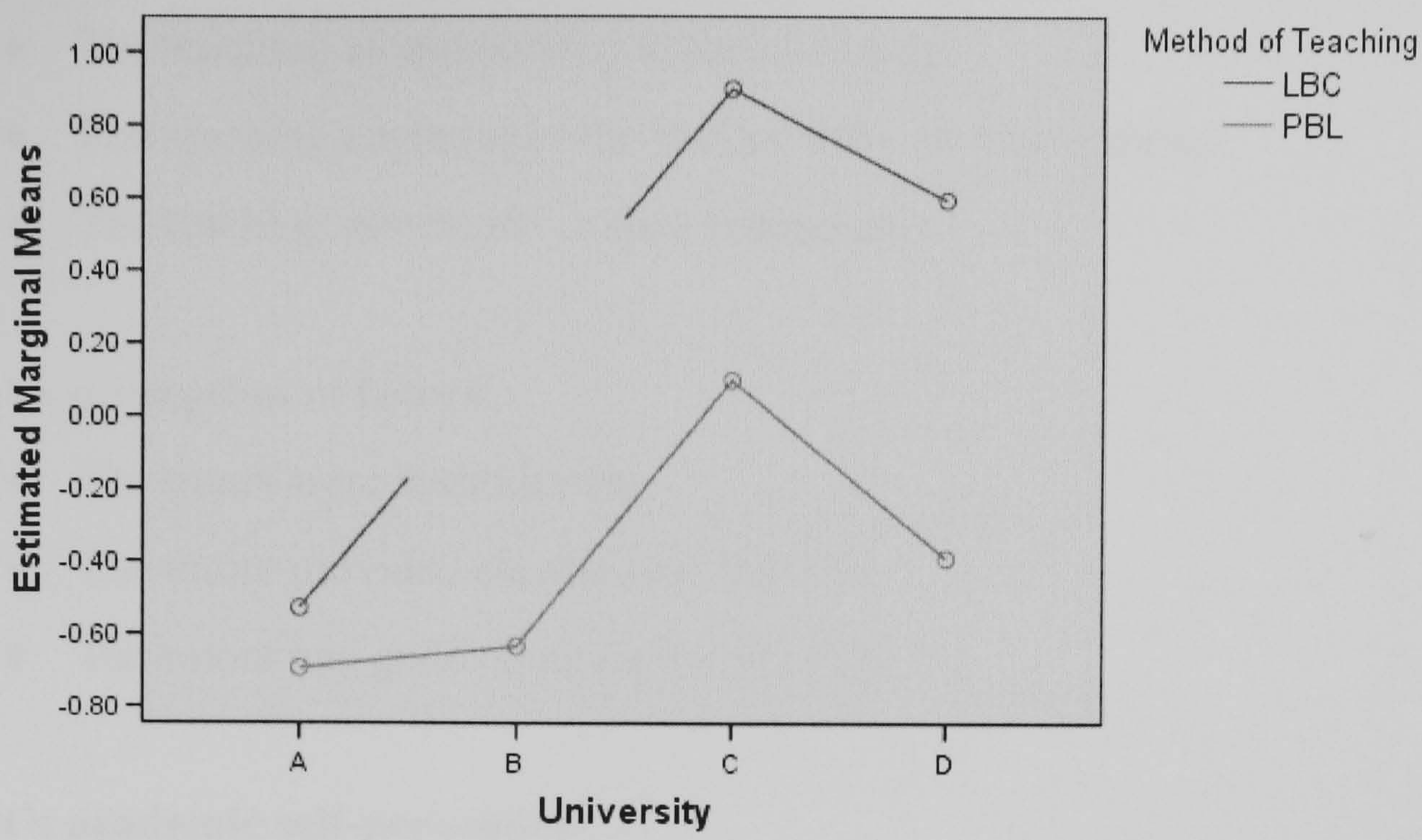
Figure 5.42 Tutors' perception of learning method for pre-clinical students



Tutors were also asked if they would consider being a PBL/LBC tutor again. Unfortunately, many tutors did not answer this question - only one response was obtained for this question, and this came from an LBC tutor who said yes.

GLM univariate analysis on *tutors' perception of learning method* indicates that the main factors of university and teaching method did not have significant results, having p-values of 0.13 and 0.11 respectively. The profile plot in figure 5.43 indicates that LBC tutors achieved a higher score than PBL tutors across all the four universities, although the two-way interaction between university and teaching method was not found to be significant, having a p-value of 0.67.

Figure 5.43 Profile plot of tutors' perception of learning method across the universities



5.20 Qualitative data

5.20.1 Pre-clinical students' responses to open-ended questions

In addition to the Likert-type scale questions, instruments for data collection also included open-ended questions where students were given the opportunity to offer their views, advice and perceptions. 422 students responded to the open-ended questions, and although the answers given shared the same theme, presentation and style were very different. Because of this, a different approach was adopted for the qualitative data analysis. Since most of the students and tutors participating in the research responded to the open-ended questions in short sentences or in bullet-point form, the themes presented were sorted into categories in order to report responses in terms of frequency (number of times that each theme was mentioned, i.e. number of students/tutors to mention each theme).

Four major themes were common from the responses given by students. For each major theme, three sub-themes emerge that cover all the statements made by students. Details of the major and sub-themes now follow.

Student's perception of learning:

- The teaching stimulated the student learning
- The teaching encouraged the student to be an active learner
- The teaching developed student competence

Student's perception of tutors:

- The tutors were authoritarian
- The tutors provided constructive criticism
- The tutors had good communication skills

Student's academic self-perception:

- The student was confident about passing the exam
- The student's problem-solving skills were well developed through this method
- The student found this experience useful for their career

Student's perception of atmosphere:

- The atmosphere made the student relaxed by using this method in the class
- The atmosphere helped the student to understand
- The student was able to ask questions whenever they wanted to

The qualitative data analysis is based on these themes and sub-themes. Students' responses to the open-ended questions are summarized in tables 5.16 and 5.17.

Table 5.16 Students' responses to open-ended questions by treatment group

Major Themes and Sub Themes		Number of times mentioned	
		LBC	**PBL**
Student's perception of learning	The teaching stimulated the student learning	5	17
	The teaching encouraged the student to be an active learner	2	4
	The teaching developed student competence	11	1
Total		**18**	**22**
Student's perception of tutors	The tutors were authoritarian	0	14
	The tutors provided constructive criticism	3	12
	The tutors had good communication skills	4	9
Total		**7**	**35**
Student's academic self-perceptions	The student was confident about passing the exam	34	4
	The student's problem solving skills were developed through this method	6	0
	The student found this experience useful for their career	6	0
Total		**46**	**4**
Student perception of atmosphere	The atmosphere made the student relaxed by using this method in the class	20	5
	The atmosphere helped the student to understand	14	6
	The student was able to ask questions whenever they want to	1	22
Total		**35**	**33**

Table 5.16 shows that pre-clinical PBL students mentioned their *perception of learning* more times than pre-clinical LBC students: it was mentioned by 22 PBL students, and 18 LBC students. The major theme of *perception of tutors* was also mentioned more by the PBL students (35 times) than by the LBC students (7 times). Pre-clinical PBL students thought that tutors were authoritarian, provided constructive criticism, and had good communication skills. It seems that authoritarian approach fit with PBL. As for *academic self-perception*, this was mentioned by 46 pre-clinical LBC students and 7 pre-clinical PBL students. It thus seems that pre-clinical LBC students are more aware of their academic self-perception than pre-clinical PBL students. Finally, the last major

theme, *perception of atmosphere*, was mentioned 35 times by pre-clinical LBC students and 33 times by pre-clinical PBL students. No clear difference between the two treatment groups can be discerned with respect to this major theme.

Looking at the sub-themes, the students' responses to the open-ended questions and their written comments echoed the quantitative findings. For example, pre-clinical LBC students achieved higher scores on examinations than pre-clinical PBL students. From the qualitative data, 34 pre-clinical LBC students said they were *confident about passing the exam*, compared to 4 pre-clinical PBL students. Similarly, pre-clinical LBC students achieved higher scores on problem-solving skills than pre-clinical PBL students. Pre-clinical LBC students mentioned problem-solving skills 6 times compared to the zero times mentioned by pre-clinical PBL students. A further breakdown into gender also confirmed the quantitative result, as pre-clinical female LBC students mentioned problem-solving skills more times than pre-clinical male LBC students (table 5.17). Pre-clinical female LBC students achieved a higher score on problem-solving skills than their male counterparts. Finally, 11 pre-clinical LBC students said that the *teaching had developed student competence*, compared to the single mention from pre-clinical PBL students. In addition, findings from the quantitative data indicate that pre-clinical LBC students are more competent than pre-clinical PBL students in their use of resources of information.

Table 5.17 Students' responses to open-ended questions by treatment group / gender

Major Themes and Sub Themes		Number of times mentioned			
		LBC		PBL	
		Gender		Gender	
		F	M	F	M
Student's perception of learning	The teaching stimulated the student learning	0	5	7	10
	The teaching encouraged the student to be an active learner	2	0	2	2
	The teaching developed student competence	10	1	1	0
Total		**12**	**6**	**10**	**12**
Student's perception of tutors	The tutors were authoritarian	0	0	7	7
	The tutors provided constructive criticism	3	0	7	5
	The tutors had good communication skills	4	0	2	7
Total		**7**	**0**	**16**	**19**
Student's academic self-perceptions	The student was confident about passing the exam	10	24	2	2
	The student's problem solving skills were developed through this method	4	2	0	0
	The student found this experience useful for their career	6	0	0	0
Total		**20**	**26**	**2**	**2**
Student perception of atmosphere	The atmosphere made the student relaxed by using this method in the class	2	18	4	1
	The atmosphere helped the student to understand	14	0	4	2
	The student was able to ask questions whenever they want to	1	0	10	12
Total		**17**	**18**	**28**	**15**

5.20.2 Tutors' responses to open-ended questions

Thirty-four tutors responded to the open-ended questions. As with the students' responses, the tutors' responses were grouped under four major themes:

- The tutor shows understanding of the subject matter
- The tutor shows commitment with respect to group functionality
- The tutor shows confidence in the learning method being used
- The tutor shows capability of using their expert knowledge

The tutors' responses are shown in table 5.18. On the whole, there were 9 mentionings by pre-clinical LBC tutors and 8 by pre-clinical PBL tutors. Looking at the individual statements, pre-clinical LBC tutors identified with *understanding of the subject* and *confidence in learning method* 4 and 3 times respectively, while pre-clinical PBL tutors mentioned each just twice. On the other hand, 4 pre-clinical PBL tutors mentioned *commitment with respect to group functionality*, whilst it was only mentioned twice by pre-clinical LBC tutors. Overall, little or no difference was observed between the treatment groups, which confirmed the quantitative result.

Table 5.18 Tutors' responses to open-ended questions by treatment group

	Number of times mentioned	
Themes	**LBC**	**PBL**
The tutor shows understanding of the subject matter	4	2
The tutor shows commitment with respect to group functionality	2	4
The tutor shows confident in the learning method being used	3	2
The tutor shows capability of using their expert knowledge	0	0
Total	**9**	**8**

The breakdown of the statements, with respect to gender, within each treatment group, does not reveal any differences (as shown in table 5.19).

Table 5.19 Tutors' responses to open-ended questions by treatment group / gender

	Teaching Method			
	LBC		PBL	
	Gender		Gender	
Themes	**Female**	**Male**	**Female**	**Male**
The tutor shows understanding of the subject matter	1	3	2	0
The tutor shows commitment with respect to group functionality	1	1	2	2
The tutor shows confident in the learning method being used	3	0	0	2
The tutor shows capability of using their expert knowledge	0	0	0	0
Total	**5**	**4**	**4**	**4**

5.21 Hypotheses revisited for pre-clinical students

In Chapter Two, fourteen hypotheses were stated regarding learning and affective behavioural differences between Saudi undergraduate pre-clinical medical students using PBL and those following a more traditional approach (LBC). These hypotheses were considered in turn.

Hypothesis 1: *It was hypothesized that students taught in PBL would have higher scores in examinations than students taught in a lecture-based format.* This hypothesis was not supported. The findings indicate that pre-clinical LBC students achieved higher scores in human genetics examinations than pre-clinical PBL students, with a mean value of 0.52 compared with -0.67. The result was statistically significant (t=11.26, p=0.01), with an effect size of -1.48 (see table 5.22).

Hypothesis 2: *It was hypothesized that students taught in PBL would have a better awareness of their genetics knowledge requirement than those taught in a lecture-based format.* This hypothesis was not supported either. Again, analysis of the results indicates that pre-clinical LBC students have a better awareness of their genetics knowledge requirement than pre-clinical PBL students, with a mean value of -0.08 against -1.12. This was found to be statistically significant (t=12.78, p=0.01), with an effect size of -1.75 (see table 5.22).

Hypothesis 3: *It was hypothesized that students taught in PBL would have better problem-solving and critical thinking skills than students taught in a lecture-based format.* This hypothesis was not supported. Analysis of the results indicates that pre-clinical LBC students had better problem-solving skills and stronger critical thinking skills than pre-clinical PBL students. A mean value of 0.57 was obtained compared with 0.47; this was found to be statistically significant (t=9.44, p=0.01). The effect size was -1.58 (see table 5.22).

Hypothesis 4: *It was hypothesized that students taught in PBL would have a higher capacity of knowledge retention (reflection) than those taught in a lecture-based format.* This hypothesis was not supported. Analysis of the results indicates that pre-clinical LBC students had a higher capacity for knowledge retention (reflection) than pre-clinical PBL students, with a mean value of -0.08 compared with -0.94. This result was found to be statistically significant (t=12.08, p=0.01), with an effect size of -1.64 (see table 5.22).

Hypothesis 5: *It was hypothesized that students taught in PBL would have better motivation than those taught in a lecture-based format.* This hypothesis was not supported. Analysis of the results indicates that pre-clinical LBC students have better motivation than pre-clinical PBL students. A mean value of 0.99 was obtained, compared with 0.87, which was found to be statistically significant (t=6.32, p=0.01). The effect size was -0.84 (see table 5.22).

Hypothesis 6: *It was hypothesized that students taught in PBL would have more confidence in conducting self-directed learning than those taught in a lecture-based format.* This hypothesis was not supported. Analysis of the results indicates that pre-clinical LBC students had more confidence in conducting self-directed learning than pre-clinical PBL students, with a mean value of -0.04 compared with -0.99. This was found to be statistically significant (t=13.63, p=0.01), with an effect size of -1.80 (see table 5.22).

Hypothesis 7: *It was hypothesized that students taught in PBL would be generally more prepared for each session than those taught in a lecture-based format.* This hypothesis was not supported. Data analysis indicates that pre-clinical LBC students had a higher level of preparation than pre-clinical PBL students, with a mean value of -0.10 compared with -1.04. This was found to be statistically significant (t=11.50, p=0.01), with an effect size of -1.58 (see table 5.22).

Hypothesis 8: *It was hypothesized that students taught in PBL would be less likely to be confused, frustrated or stressed when learning about medicine than students taught in a lecture-based format.* This hypothesis was not supported. The pre-clinical PBL students had a slightly higher mean score (0.31) than pre-clinical LBC students (0.30), indicating that pre-clinical PBL students have higher levels of frustration, stress and confusion than pre-clinical LBC students. However, this was not found to be statistically significant (t=-0.05, p=0.96) (see table 5.22).

Hypothesis 9: *It was hypothesized that students taught in PBL would be less likely to be confused, frustrated or stressed when working with patients than students taught in a lecture-based format.* There was some evidence to indicate that pre-clinical PBL students had lower levels of frustration, stress and confusion when working with patients than pre-clinical LBC students. A mean value of 0.22 was obtained, compared with 0.28. This hypothesis was not supported, however, as the result was not statistically significant (t=0.45, p=0.65) (see table 5.22).

Hypothesis 10: *It was hypothesized that students taught in PBL would be less likely to be confused, frustrated or stressed regarding a career focusing on medicine than students taught in a lecture-based format.* This hypothesis was not supported. Analysis of the results indicates that pre-clinical LBC students had lower levels of frustration, stress and confusion than pre-clinical PBL students, with a mean value of 0.13 compared with -1.18. This was found to be statistically significant (t=13.95, p=0.01), with an effect size of -1.92 (see table 5.22).

Hypothesis 11: *It was hypothesized that students taught in PBL would be less likely to be confused, frustrated or stressed regarding problems associated with medicine than students taught in a lecture-based format.* This hypothesis was not supported. Analysis of the results indicates that pre-clinical LBC students had lower levels of frustration, stress and confusion regarding problems associated with medicine than pre-clinical PBL students. A mean value of 0.15 was obtained compared with -0.14, which was found to be statistically significant (t=2.08, p=0.04). The effect size was -0.28 (see table 5.22).

Hypothesis 12: *It was hypothesized that students taught in PBL would have a better learning experience than those taught in a lecture-based format.* This hypothesis was not supported. Again, analysis of the results indicates that pre-clinical LBC students had a better learning experience than pre-clinical PBL students, with a mean value of -0.10 compared with -1.10. This was found to be statistically significant (t=12.23, p=0.01), with an effect size of -1.64 (see table 5.22).

Hypothesis 13: *It was hypothesized that students taught in PBL would be more competent in the use of resources available than students taught in a lecture-based format.* This hypothesis was not supported. Data analysis indicates that pre-clinical LBC students had a higher level of competence in the use of resources of information available than pre-clinical PBL students. A mean value of -0.06 was obtained, compared with -0.22, which was not statistically significant (t=1.19, p=0.24) (see table 5.22).

Hypothesis 14: *It was hypothesized that PBL tutors would have a higher opinion of PBL methods than LBC tutor*s of LBC methods. This hypothesis was not supported. Analysis of the results indicates that pre-clinical LBC tutors had a higher perception of the learning method than pre-clinical PBL tutors, with a mean value of 0.32 compared with -0.43. This was not statistically significant (t=2.01, p=0.06) (see table 5.22).

5.22 Pre data

A check was run on the extent to which students remained in their original groups. Table 5.20 shows the results of this check. It is clear that only a very small proportion of students changed groups. Nevertheless, it is appropriate to see if these changes had an impact. Therefore, the pre test data was used as a control to reanalyse the post data. A regression procedure was used in which the post test measure was the outcome and the pre test measure was the control. Visual inspection of the scatter graphs showed satisfactory relations. The relevant correlations are given below (table 5.21).

Table 5.20 Number of students reporting membership of group

		Pre Intervention		Total
		LBC	PBL	
Post Intervention	LBC	112	3	115
	PBL	3	114	117
Total		115	117	232

Table 5.21 Correlation coefficients (r) between pre and post data for all subscales for pre-clinical students and tutors

Subscales	r
Fulfil knowledge requirement	0.20**
Problem-solving and critical thinking skills	0.22**
Knowledge retention (reflection)	0.25**
Motivation	0.11
Self-directed skills	0.21**
Level of preparation	0.18**
Learning about medicine	0.45**
Working with patients	0.46**
Career focusing on medicine	0.22**
Problems associated with medicine	0.46*
Learning experience	0.26**
Resources of information	0.29**
Tutors' perception of learning method	0.16

** Sig at 1%; * Sig at 5%

The residuals from the regression were then examined. The effect sizes of the analysis using the residuals were compared with the effect sizes calculated assuming random assignment (table 5.22). The effect sizes from the residuals were very similar to the effect sizes assuming random assignment. They were a little lower, but this is expected because the controls reduced the standard deviation. The conclusion reached earlier, therefore, remains the same.

No significant difference was observed between pre-clinical PBL and LBC students. For the pre data, see Appendix E.

Table 5.22 Comparing effect sizes from residuals and random assignment

Subscales	From Residuals		Random Assignment	
	Effect size	Std Error	Effect size	Std Error
Exam test total	-	-	-1.48	0.15
Fulfil knowledge requirement	-1.35	0.15	-1.75	0.16
Problem-solving and critical thinking skills	-1.27	0.15	-1.58	0.15
Knowledge retention (reflection)	-1.29	0.15	-1.64	0.15
Motivation	-0.52	0.13	-0.84	0.14
Self-directed skills	-1.23	0.14	-1.80	0.16
Level of preparation	-1.10	0.14	-1.58	0.15
Learning about medicine	-0.09	0.13	0.01	0.13
Working with patients	-0.25	0.13	-0.06	0.13
Career focusing on medicine	-1.28	0.15	-1.92	0.16
Problems associated with medicine	-0.30	0.13	-0.28	0.13
Learning experience	-1.32	0.15	-1.64	0.15
Resources of information	0.06	0.13	-0.16	0.13
Tutors' perception of learning method	-0.86	0.49	-0.86	0.49

Section IV: Results and Data Analysis

Chapter Six

Results and Data Analysis II: Quantitative and Qualitative Data for Clinical Students

Chapter Six
Results and Data Analysis II: Quantitative and Qualitative Data for Clinical Students

6.1 Introduction

As with Chapter Five, this chapter presents the results and data analysis; but now we concentrate on clinical students. As in the previous chapter, the quantitative results and data analysis are presented, first assuming random assignment, followed by the qualitative results and data analysis. The methodology used in Chapter Five is also used in this chapter; therefore, we concentrate on reporting the results rather than on the techniques used.

6.2 Quantitative data

6.2.1 Distribution by treatment group

A total of 252 clinical students took part in this research, of which 125 (49.2%) were placed in the PBL group and 127 (50.8%) in the LBC group. Placement within groups was assigned randomly.

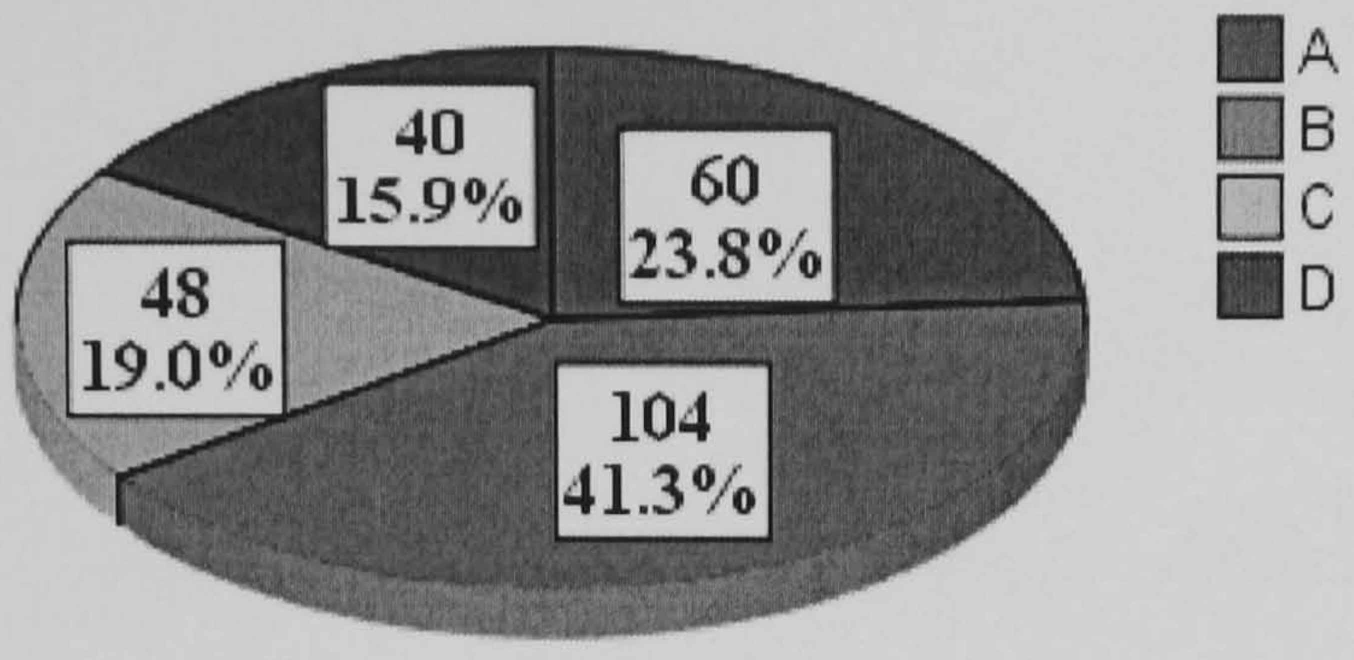
6.2.2 Distribution by gender

In terms of gender composition, 132 (52.4%) of the 252 clinical students were male and 120 (47.6%) were female.

6.2.3 Distribution by university

In terms of distribution across the universities, 60 (23.8%) of the 252 clinical students were from University A, 104 (41.3%) from University B, 48 (19.0%) from University C and 40 (15.9%) from University D (see figure 6.1).

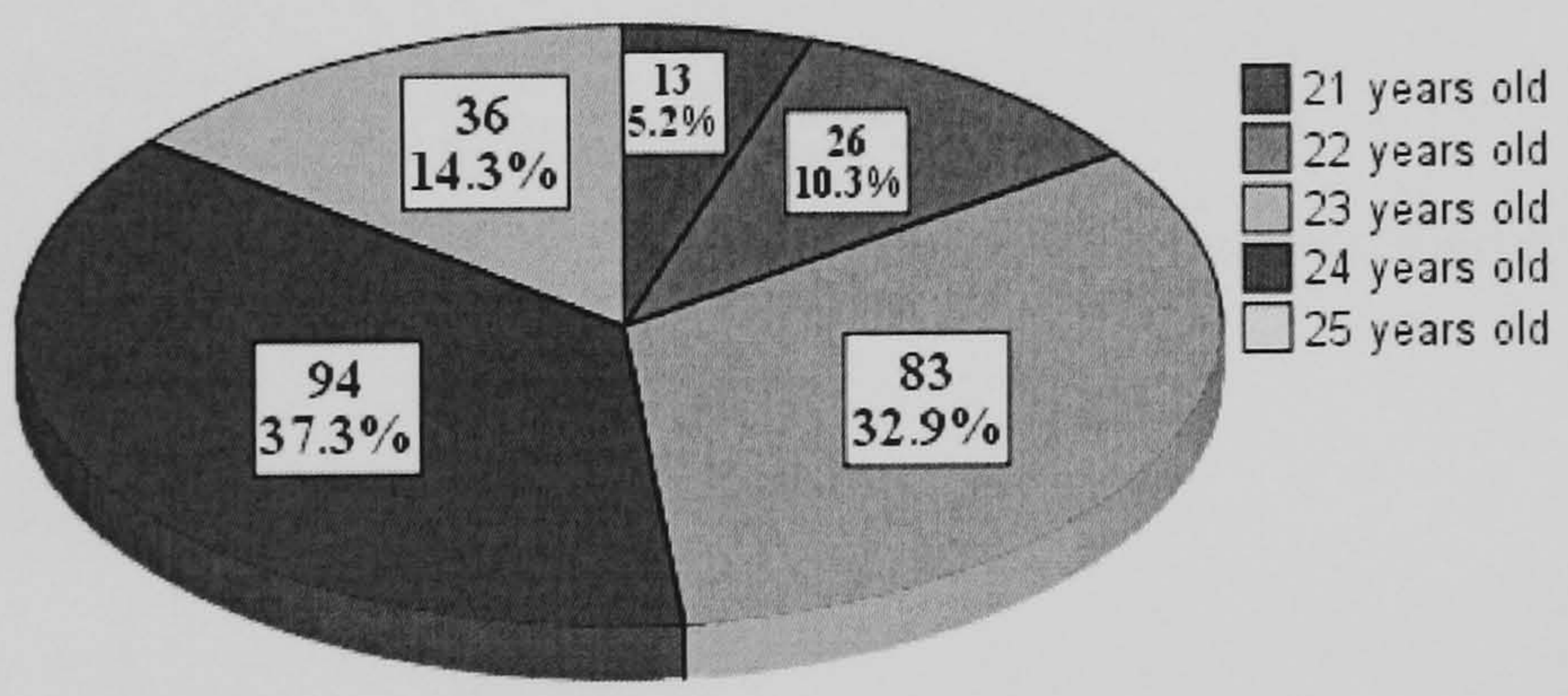
Figure 6.1 Composition by university: number and percentage of clinical students



6.2.4 Distribution by age

The ages of the participating clinical students ranged from 21 years to 25 years old, with a mean age of 23.5 years (see figure 6.2 for details). The majority (84.5%) of clinical students were between the ages of 23 and 25 years.

Figure 6.2 Age distribution: number and percentage of clinical students



The composition of treatment groups by stratification factors for clinical students is shown in table 6.1.

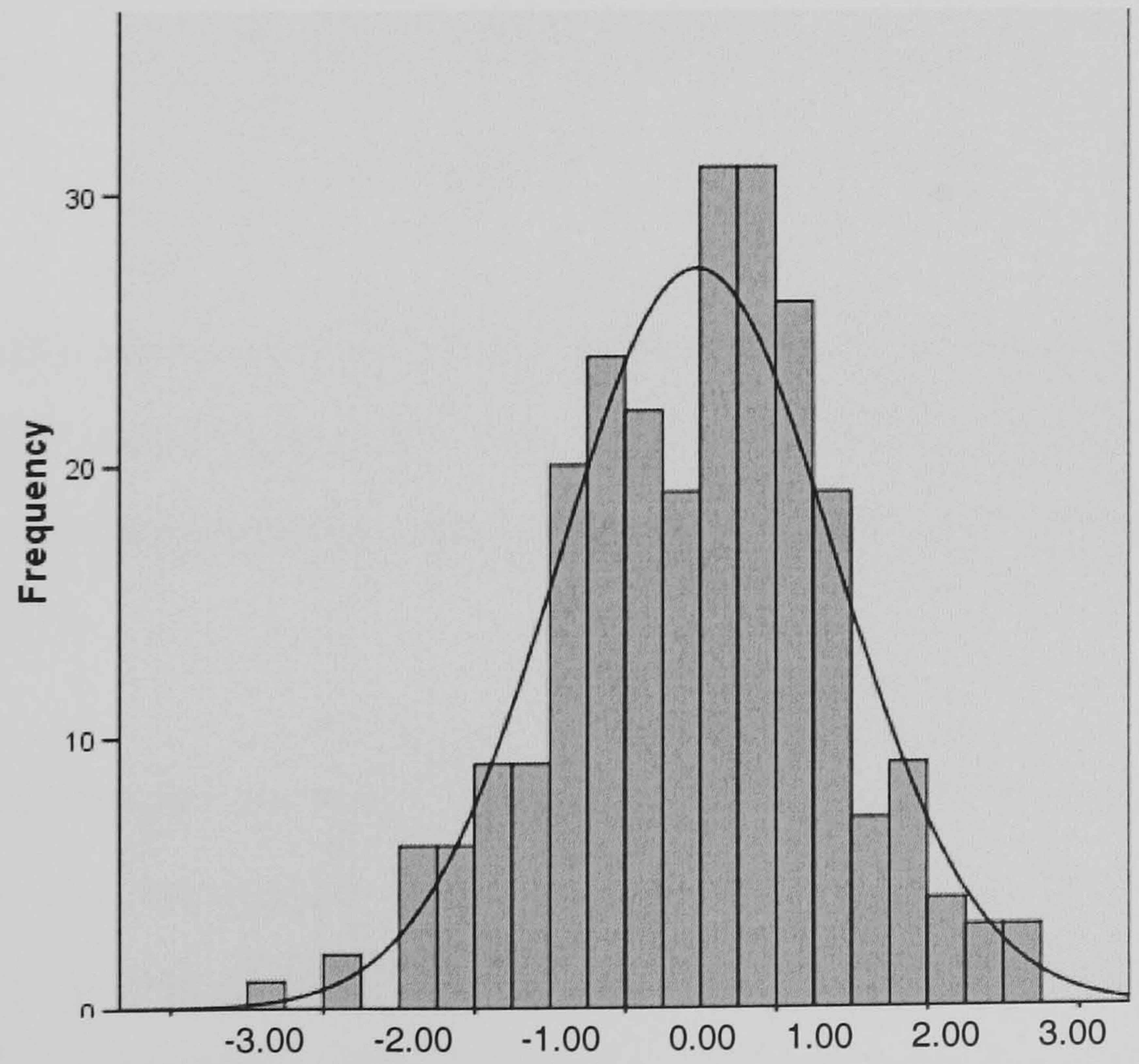
Table 6.1 Treatment group composition by stratification factors for clinical students

	LBC		PBL		
	Gender		Gender		
University	Female	Male	Female	Male	Total
A	14	16	14	16	60
B	24	28	24	28	104
C	13	12	11	12	48
D	11	10	9	10	40
Total	61	66	59	66	252
Total	127		125		252

6.3 Learning experience

Figure 6.3 shows the histogram of the normalized score for all students.

Figure 6.3 Learning experience for clinical students

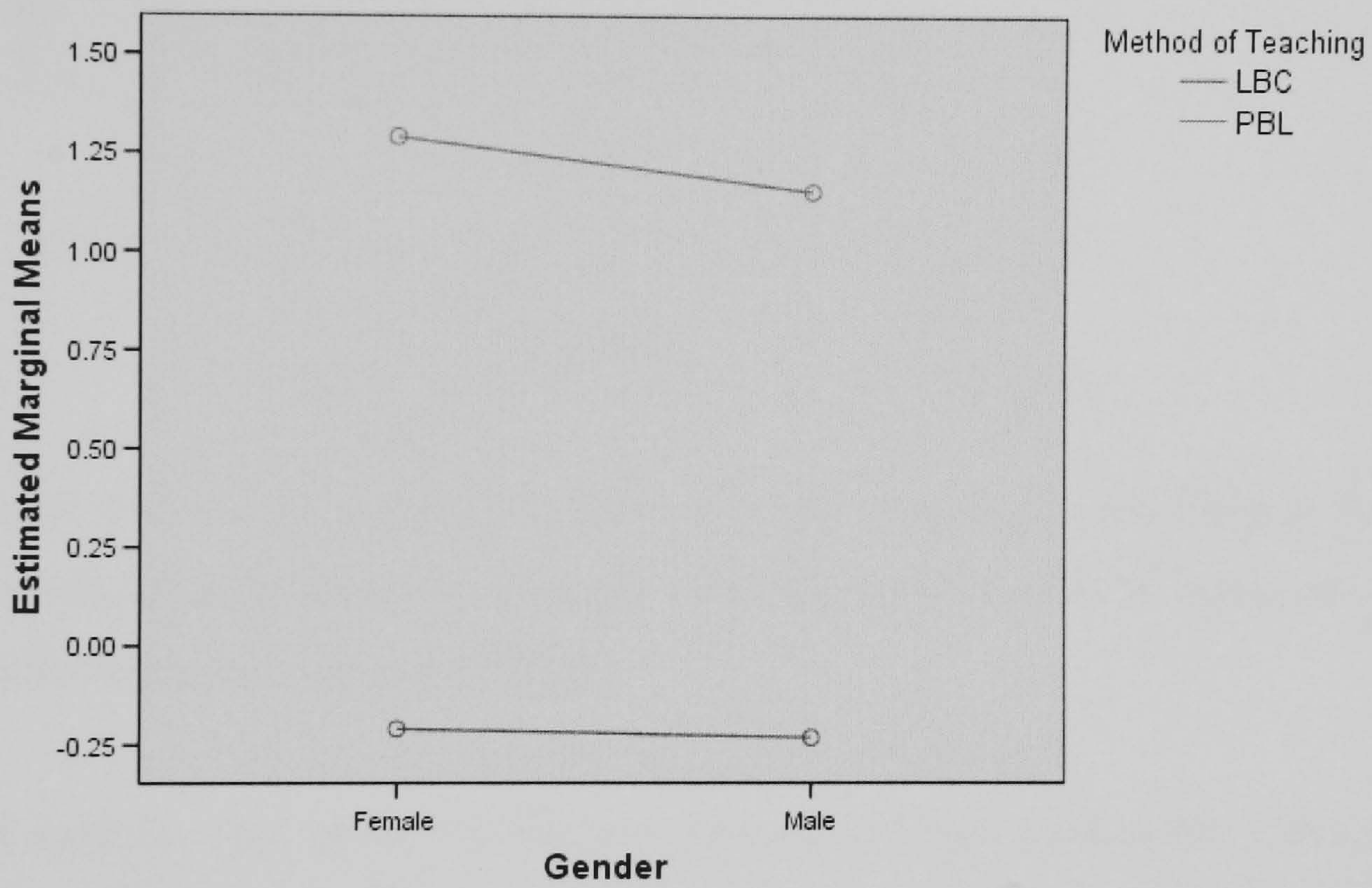


Clinical PBL students gave their learning experience a higher mean score (1.21) than clinical LBC students (-0.23), giving a significant mean difference (t=-20.12, p=0.01).

The effect size for the clinical students' learning experience was 2.54,[1] with a standard error of 0.17. These results show that clinical PBL students had a better learning experience than clinical LBC students.

From the GLM univariate analysis, significant results were observed regarding the relationship between teaching method (p=0.01) and university (p=0.03). The main factor of gender was not significant (p=0.22), indicating a similar rating for both male and female students, irrespective of the teaching method (see figure 6.4).

Figure 6.4 Profile of learning experience across gender



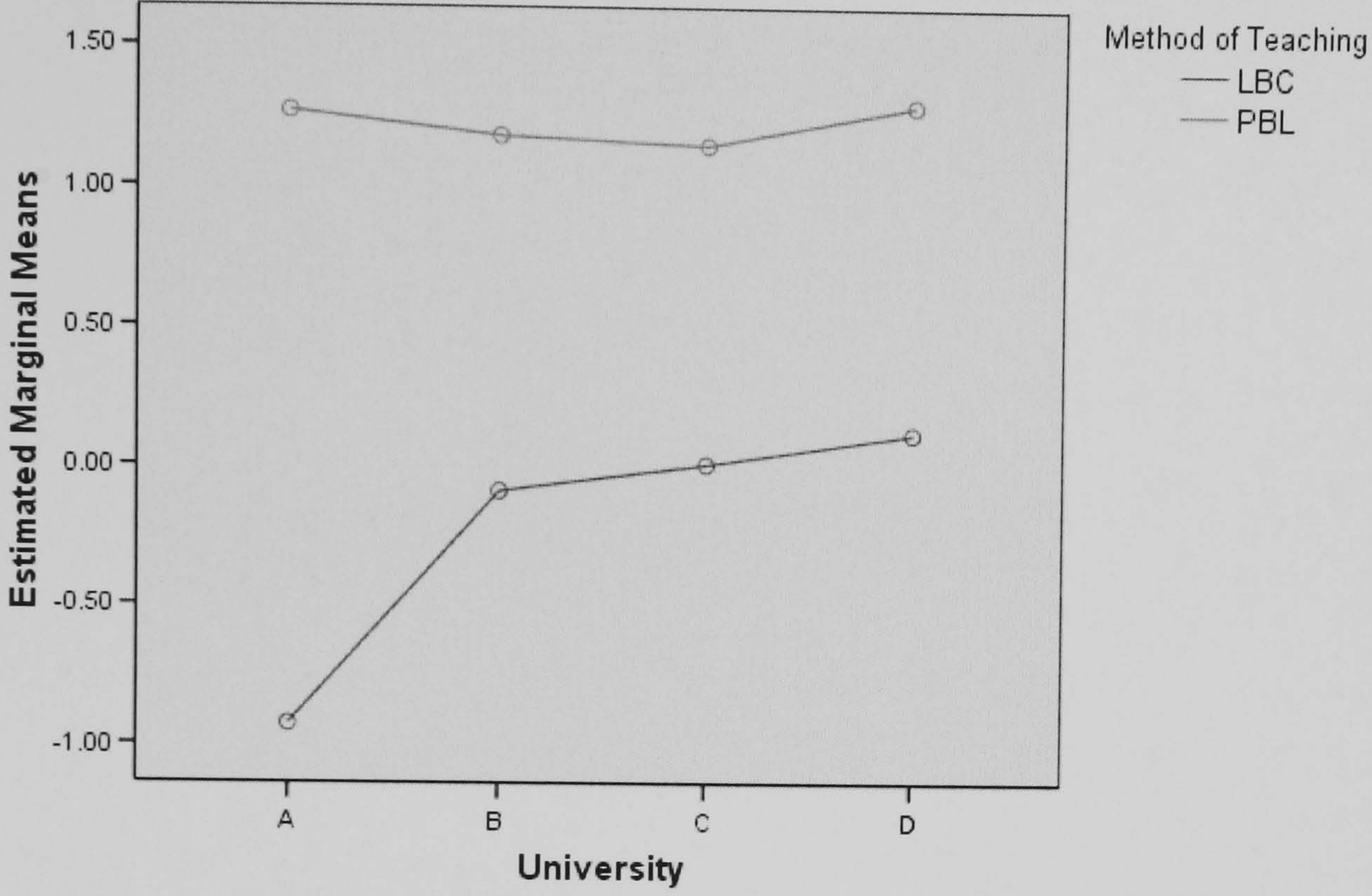
Looking at learning experience across the universities shows that in both groups (LBC and PBL), all four universities performed better with PBL compared to LBC. There was very little difference in the mean value across the universities with PBL, as shown in figure 6.5.

There were no significant two-way interactions between gender and teaching method (p=0.38), while the interaction was significant between university and teaching method (p=0.01). Across all four universities, clinical students achieved higher scores when the teaching method was PBL compared to LBC. This could be because clinical

[1] Coe (2000) defines effect size as a way of quantifying the effectiveness of a particular intervention relative to some comparison.

students learn more through working on actual practical problems, as is the case with PBL, than with the classroom-based examples of LBL.

Figure 6.5 Profile of learning experience across the universities



Looking at each of the eight items under *learning experience* (see Chapter 5.3), the mean of clinical PBL students was higher than that of clinical LBC students. All the mean differences were also significant.

As well as these eight items, the DQ questionnaire solicited information from clinical students on other aspects of their learning experience during the human genetics unit. The information collated considered their participation, the use of case studies in class, and whether or not they enjoyed the experience. They were also asked if they had ever been exposed to 'problem-based learning' as an educational strategy, or if they had ever taken a course that included a significant amount of information on the molecular bases of genetic diseases, chromosomal aberrations and other genetic diseases. An analysis of the students' responses now follows.

Sixteen percent (16%) of the clinical PBL students said that they had previously participated in classes which included the use of case studies. The corresponding percentage for the clinical LBC students was just over 18% (see table 6.2); the difference between the two groups is almost 2%.

Table 6.2 Use of case studies

			Have you ever participated in classes which included the use of case studies?		Total
			No	Yes	
Method of Teaching	LBC	Count	104	23	127
		% within Method of Teaching	81.9%	18.1%	100.0%
	PBL	Count	102	20	122
		% within Method of Teaching	83.6%	16.4%	100.0%
Total		Count	206	43	249
		% within Method of Teaching	82.7%	17.3%	100.0%

ChiSq=0.13, df=1, p=0.72

There was no significant association between teaching method (LBC or PBL) and whether or not case studies had been used in class. The Pearson Chi-Square statistic was found to be 0.13 with a p-value of 0.72. Overall, only 17% (n=43) of clinical students had participated in classes which included the use of case studies; the corresponding percentage for pre-clinical students is nearly 30%.

Of those clinical PBL students who said they had participated in classes involving the use of case studies, only 30% said that they enjoyed learning in this way. The corresponding percentage for pre-clinical LBC students is higher at nearly 35% (see table 6.3); no significant association was observed (Chi-Square statistic=0.11, p-value=0.74). Overall, of the 43 clinical students that had participated in classes involving the use of case studies, 32.6% (n=14) liked learning from case studies.

Table 6.3 Number of clinical students who liked learning from case studies

			If your answer to item 4 was 'YES', did you like learning from case studies?		Total
			No	Yes	
Method of Teaching	LBC	Count	15	7	23
		% within Method of Teaching	65.2%	34.8%	100.0%
	PBL	Count	14	6	20
		% within Method of Teaching	70.0%	30.0%	100.0%
Total		Count	29	14	43
		% within Method of Teaching	67.4%	32.6%	100.0%

ChiSq=0.11, df=1.0, p=0.74

Only 2.5% of clinical PBL students had previously been exposed to a 'problem-based learning' educational strategy. The corresponding percentage for clinical LBC students is even smaller at 1.6% (see table 6.4); no significant association was observed (Chi-Square statistic=0.27, p-value=0.61). Overall, only 2.0% (n=5) of clinical students had previously been exposed to a 'problem-based learning' educational strategy.

Table 6.4 Problem-based learning

			Have you ever been exposed to an educational strategy identified as 'problem-based learning' before?		Total
			No	Yes	
Method of Teaching	LBC	Count	125	2	127
		% within Method of Teaching	98.4%	1.6%	100.0%
	PBL	Count	117	3	120
		% within Method of Teaching	97.5%	2.5%	100.0%
Total		Count	242	5	247
		% within Method of Teaching	98.0%	2.0%	100.0%

ChiSq=0.27, df=1.0, p=0.61

The majority of the clinical students, irrespective of their treatment group, had taken a course with a significant amount of information on *molecular bases of genetic diseases*, *chromosomal aberrations* and *other genetic diseases*. The percentages for clinical PBL students were 99.2%, 99.2% and 97.6% respectively, whilst the corresponding percentages for clinical LBC students were 96.9%, 95.3% and 97.6% respectively (see tables 6.5, 6.6 and 6.7). No significant association was observed between the treatment groups for *molecular bases of genetic diseases* (Chi-Square statistic=1.72, p-value=0.19); *chromosomal aberrations* (Chi-Square statistic=3.47, p-value=0.06) and *other genetic diseases* (Chi-Square statistic=0.01, p-value=0.97).

Table 6.5 Molecular bases of genetic diseases

			Have you ever taken a course that included a significant amount of information about molecular bases of genetic diseases?		Total
			No	Yes	
Method of Teaching	LBC	Count	4	124	128
		% within Method of Teaching	3.1%	96.9%	100.0%
	PBL	Count	1	122	123
		% within Method of Teaching	.8%	99.2%	100.0%
Total		Count	5	246	251
		% within Method of Teaching	2.0%	98.0%	100.0%

ChiSq=1.72, df=1.0, p=0.19

Table 6.6 Chromosomal aberrations

			Have you ever taken a course that included a significant amount of information about chromosomal aberrations?		Total
			No	Yes	
Method of Teaching	LBC	Count	6	122	128
		% within Method of Teaching	4.7%	95.3%	100.0%
	PBL	Count	1	122	123
		% within Method of Teaching	.8%	99.2%	100.0%
Total		Count	7	244	251
		% within Method of Teaching	2.8%	97.2%	100.0%

ChiSq=3.47, df=1.0, p=0.06

Table 6.7 Other genetic diseases

			Have you ever taken a course that included a significant amount of information about other genetic diseases?		Total
			No	Yes	
Method of Teaching	LBC	Count	3	124	127
		% within Method of Teaching	2.4%	97.6%	100.0%
	PBL	Count	3	120	123
		% within Method of Teaching	2.4%	97.6%	100.0%
Total		Count	6	244	250
		% within Method of Teaching	2.4%	97.6%	100.0%

ChiSq=0.00, df=1.0, p=0.97

6.4 Caring experience

Information about the caring experience of clinical students with respect to sickle cell anaemia and Down's syndrome was also solicited. About thirty percent (30.1%) of the clinical PBL students said that they had experienced caring for persons with sickle cell anaemia; the corresponding percentage for clinical LBC students was lower at 27.3%. (see table 6.8). No significant association was observed (Chi-Square statistic=0.23, p-value=0.62). Overall, 28.7% of all clinical students had experienced caring for persons with sickle cell anaemia.

Table 6.8 Sickle cell anaemia

			Do you have experience in caring for persons with sickle cell anaemia?		Total
			No	Yes	
Method of Teaching	LBC	Count	93	35	128
		% within Method of Teaching	72.7%	27.3%	100.0%
	PBL	Count	86	37	123
		% within Method of Teaching	69.9%	30.1%	100.0%
Total		Count	179	72	251
		% within Method of Teaching	71.3%	28.7%	100.0%

ChiSq=0.23, df=1.0, p=0.62

For Down's syndrome, 22.0% of clinical PBL students had experienced caring for persons with this disease, while the corresponding percentage for clinical LBC is slightly lower at 19.7% (see table 6.9); no significant association was observed (Chi-Square statistic=0.20, p-value=0.66). Overall, a lower percentage (20.7%) of all clinical students had experienced caring for people with Down's syndrome than had cared for people with sickle cell anaemia (28.7%).

Table 6.9 Down's syndrome

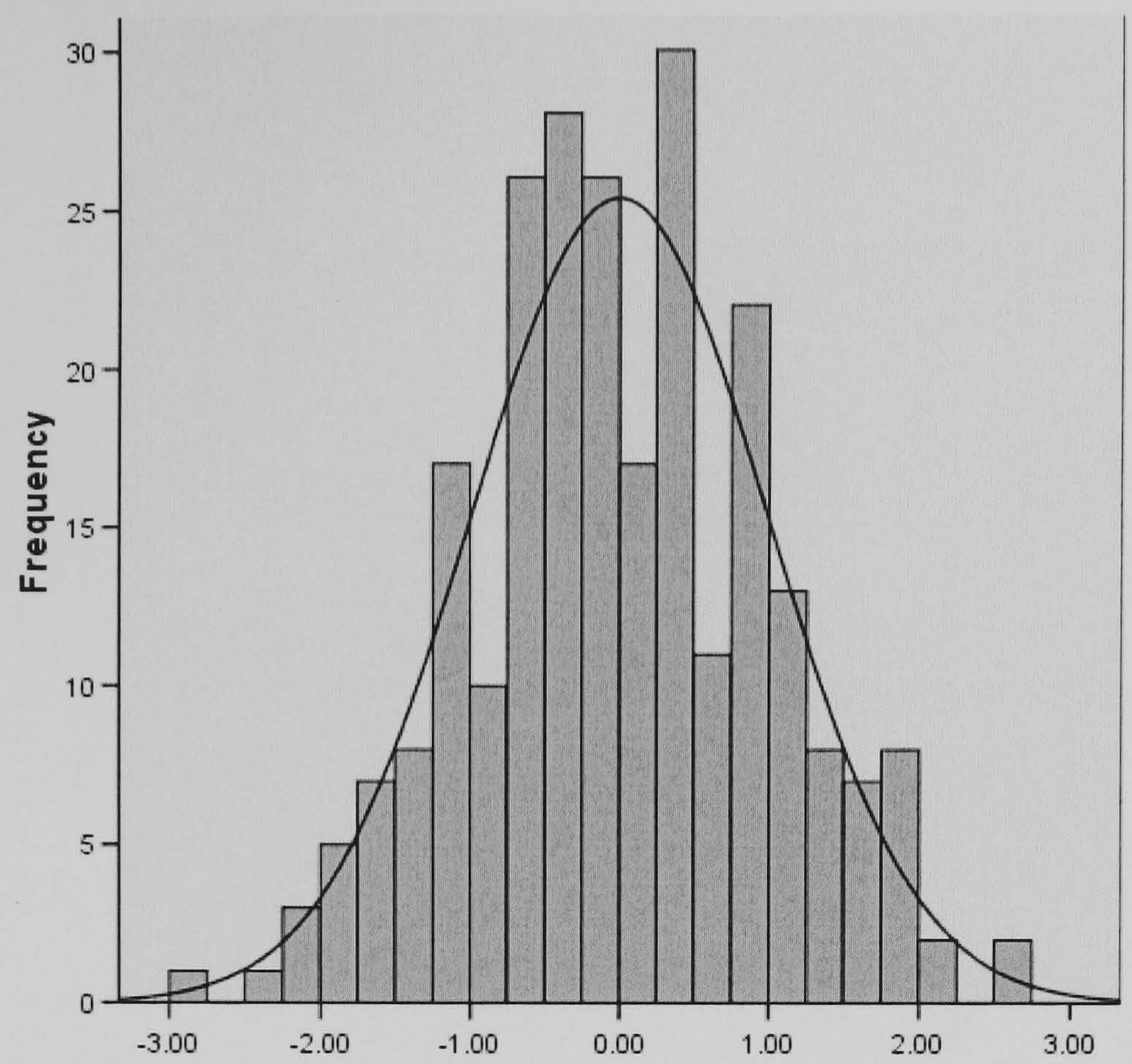
			Do you have experience in caring for persons with Down's syndrome?		Total
			No	Yes	
Method of Teaching	LBC	Count	102	25	127
		% within Method of Teaching	80.3%	19.7%	100.0%
	PBL	Count	96	27	123
		% within Method of Teaching	78.0%	22.0%	100.0%
Total		Count	198	52	250
		% within Method of Teaching	79.2%	20.8%	100.0%

ChiSq=0.20, df=1.0, p=0.66

6.5 Human genetics unit examination

Analysis from the examination indicated that clinical PBL students scored a higher mean than clinical LBC students: the mean score for clinical PBL students was 0.03, whereas that for clinical LBC students was -0.03. The mean difference was not significant, however (t=-0.48, p=0.63); the effect size was 0.06, with a standard error of 0.13. Thus in summary, clinical PBL students achieved higher, but not significantly higher, marks in the examination test than clinical LBC students. A histogram of the human genetics unit examination is shown in figure 6.6.

Figure 6.6 Post-exam test total for clinical students

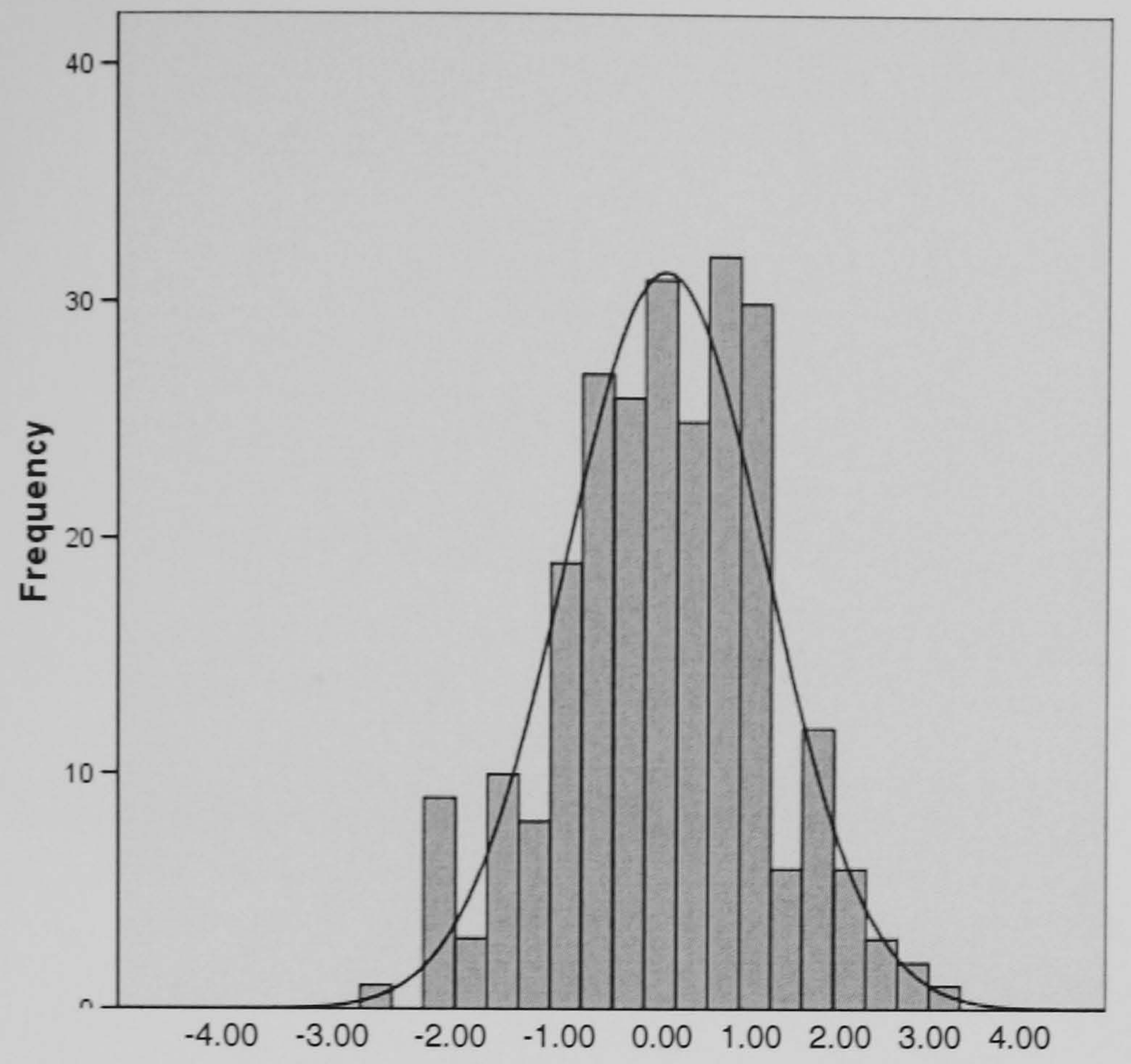


GLM univariate analysis on examination results indicates that the main factors of gender and teaching method were not significant (p-values of 0.97 and 0.40 respectively), while the main factor of university was significant (p-value=0.01). The two-way interactions between gender and teaching method and between university and teaching method were not significant, having p-values of 0.28 and 0.12 respectively.

6.6 Fulfil knowledge requirement

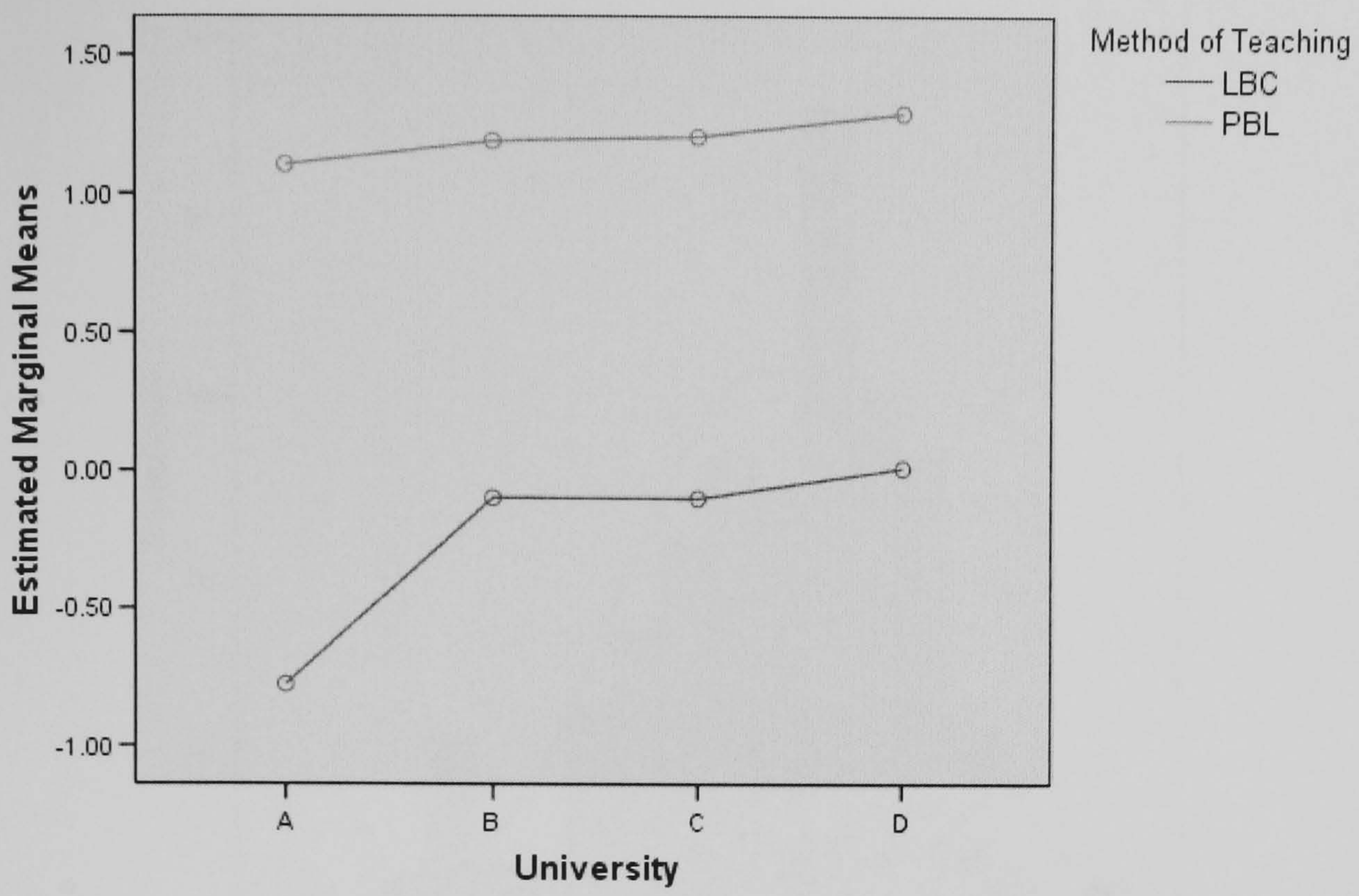
Clinical PBL students had a higher mean score than clinical LBC students on *fulfil knowledge requirement*; the mean score for clinical PBL students was 1.19, whereas that for clinical LBC students was -0.23. The mean difference was significant (t=19.50, p=0.01), and the effect size was 2.46 with a standard error of 0.17. Thus clinical PBL students achieved a significantly higher score on *fulfil knowledge requirement* than clinical LBC students. In fact, looking at the individual indicators on this scale, clinical PBL students achieved higher scores than clinical LBC students on all the indicators. A histogram of *fulfil knowledge requirement* is shown in figure 6.7.

Figure 6.7 Fulfil knowledge requirement for clinical students



GLM univariate analysis on *fulfil knowledge requirement* indicates that the main factor of gender was not significant (p=0.83), whereas teaching method and university show significant results with p-values of 0.01 and 0.01 respectively. The profile plot across the universities (figure 6.8) indicates that all four universities achieved a higher score when using the PBL method than the LBC method. The two-way interaction between gender and teaching method was not significant (p=0.15), while that between university and teaching method was found to be significant (p=0.01).

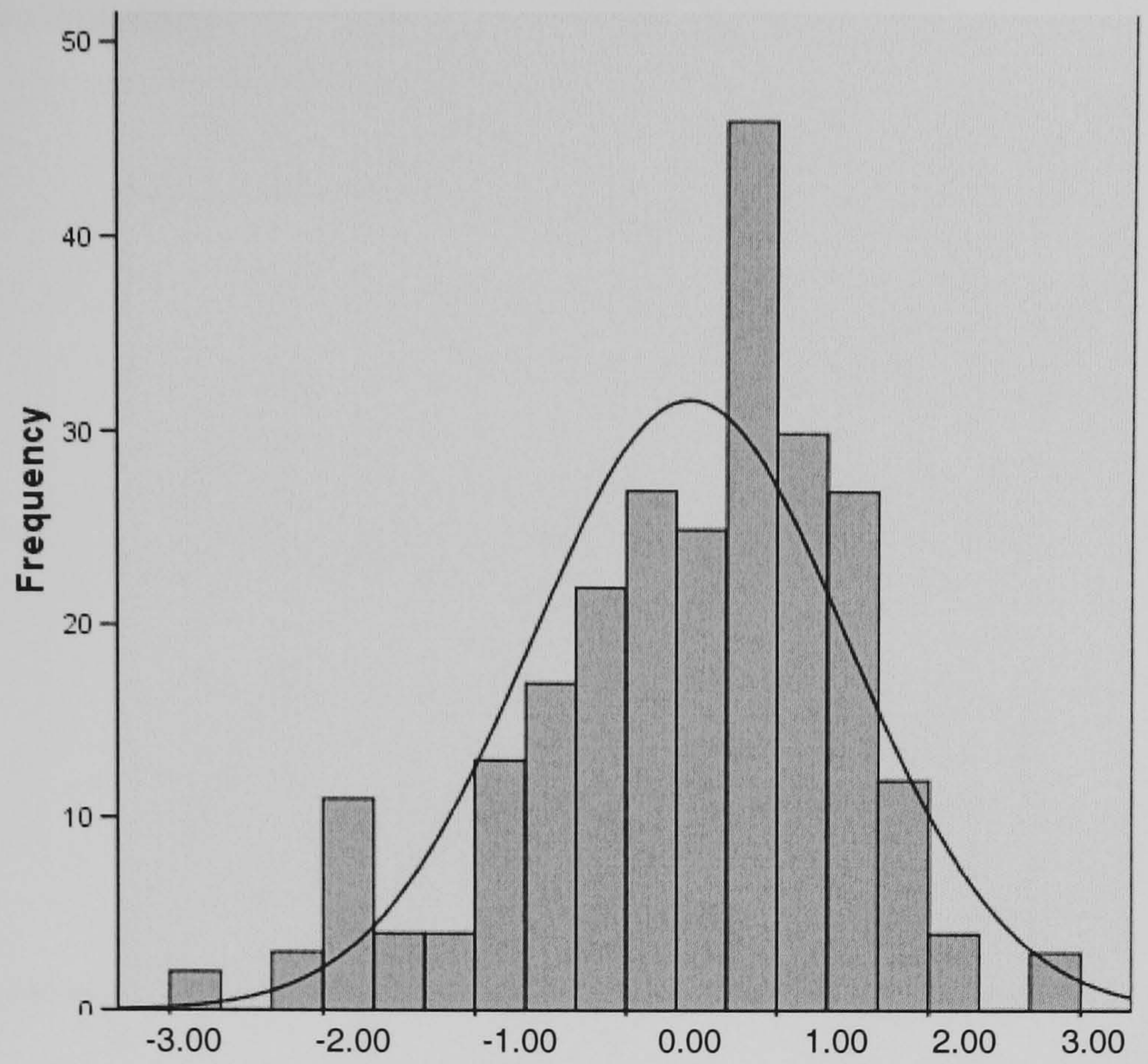
Figure 6.8 Profile plot of fulfil knowledge requirement across the universities



6.7 Problem-solving and critical thinking skills

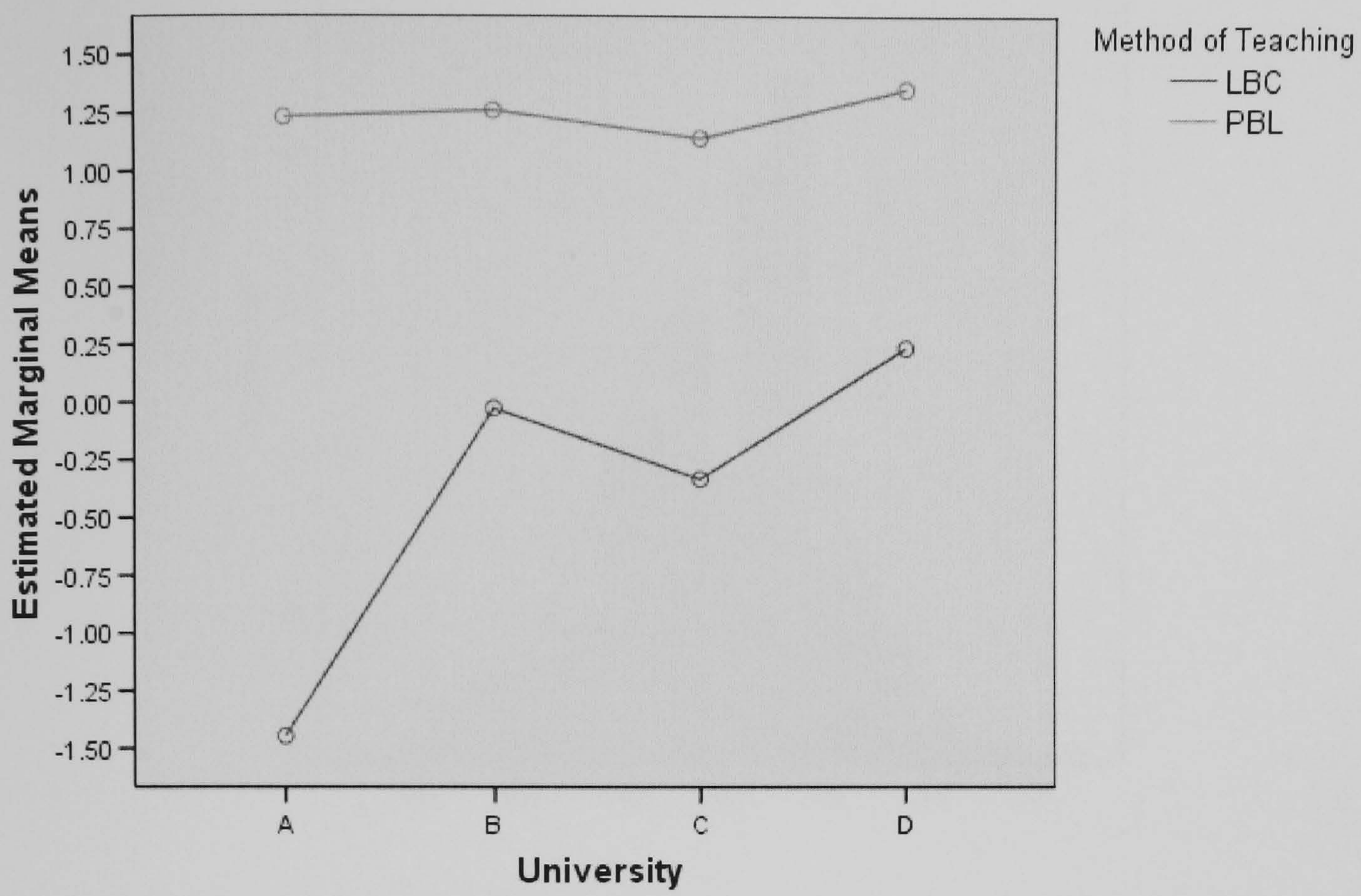
Clinical PBL students had a higher mean score than clinical LBC students on *problem-solving and critical thinking skills*: the mean score for clinical PBL students was 1.24, whereas that for clinical LBC students was -0.37. The mean difference was significant (t=-19.11, p=0.01), and the effect size was 2.43 with a standard error of 0.19. Thus clinical PBL students achieved significantly higher scores on *problem-solving and critical thinking skills* than clinical LBC students. In fact, clinical PBL students achieved higher scores than clinical LBC students on all six of the items on this scale. A histogram of *problem-solving and critical thinking skills* is shown in figure 6.9.

Figure 6.9 Problem-solving and critical thinking skills for clinical students



GLM univariate analysis of *problem-solving and critical thinking skills* indicates that the main factor of gender was not significant (p=0.85), while those of teaching method and university both showed significant results, with p-values of 0.01 and 0.01 respectively. The profile plot across the universities (figure 6.10) indicates that students in all four universities achieved a higher score when using the PBL method than the LBC method. Little difference was observed across universities with regards the PBL method only, but for the LBC method, more variation is observed across universities, as indicated by the profile plot. This could be due to unique approaches used by tutors when lecturing; problem-based learning, being less tutor-centred, might therefore be less affected by the idiosyncrasies of different tutors. The two-way interaction between gender and teaching method was found not to be significant (p=0.35), whereas that between university and teaching method was significant (p=0.01). It is the second time that university A had a low score for LBC.

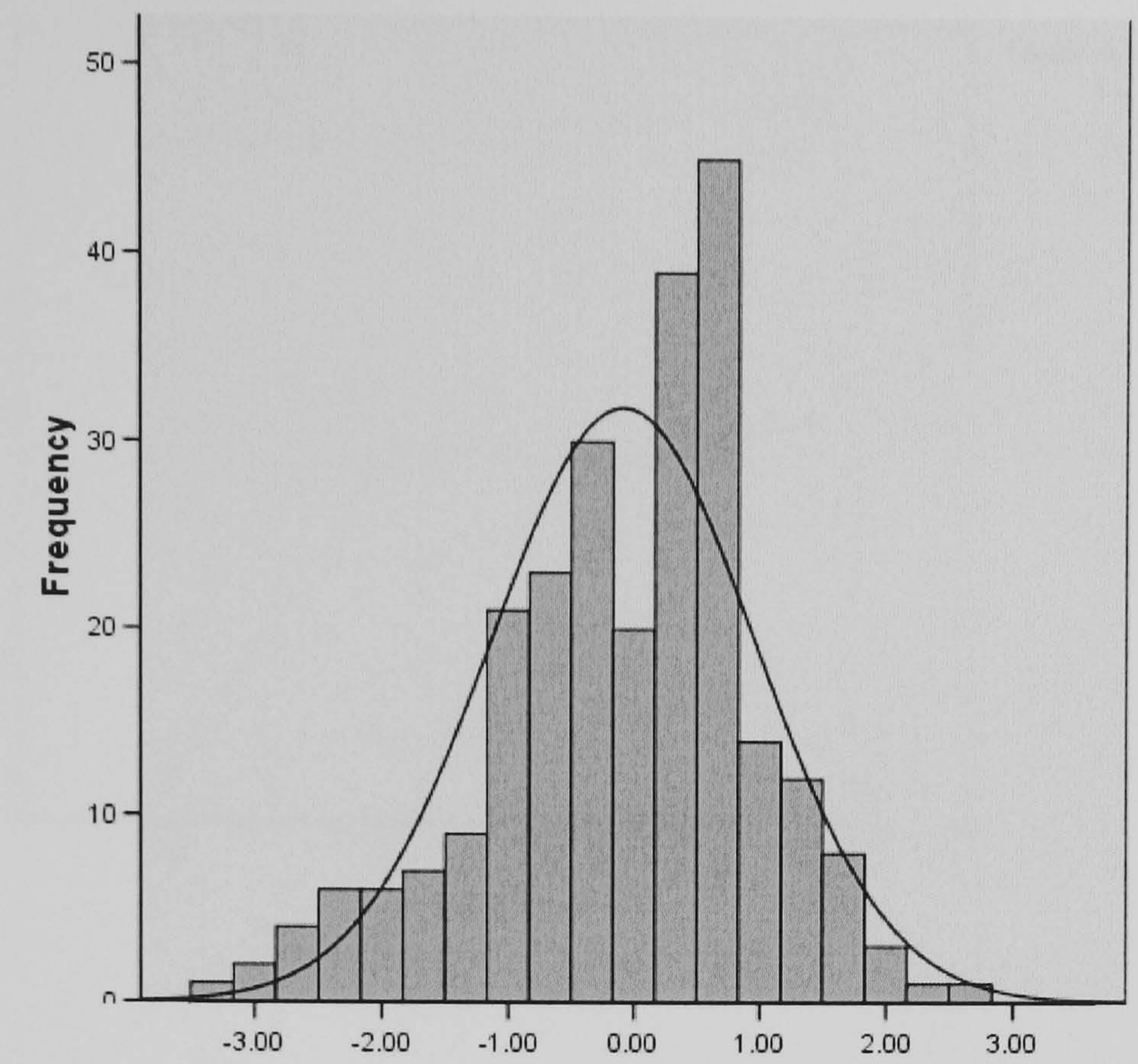
Figure 6.10 Profile plot of problem-solving and critical thinking skills across the universities



6.8 Knowledge retention (reflection)

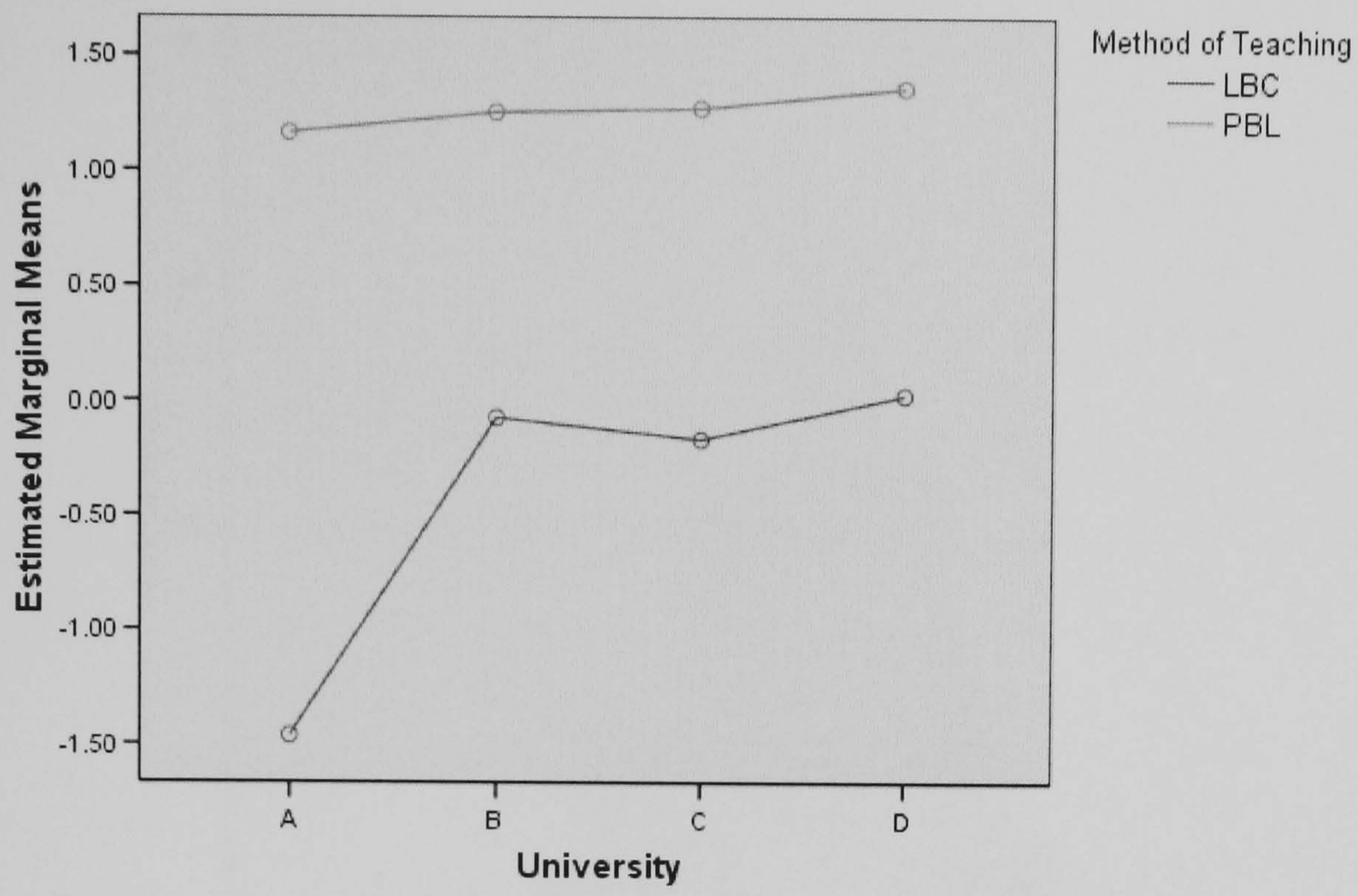
Clinical PBL students had a higher mean score (1.25) than clinical LBC students (-0.40) on *knowledge retention (reflection)*, with a significant mean difference (t= -20.12, p=0.01). The effect size was 2.53 with a standard error of 0.17. Thus clinical PBL students achieved a significantly higher score on *knowledge retention (reflection)* than clinical LBC students. A histogram of *knowledge retention (reflection)* is shown in figure 6.11.

Figure 6.11 Knowledge retention (reflection) for clinical students



GLM univariate analysis on *knowledge retention (reflection)* indicates that the main factor of gender was not significant (p=0.71), while those of teaching method and university both showed significant results, with p-values of 0.01 and 0.01 respectively. The profile plot across the universities (figure 6.12) indicates that students in all four universities achieved a higher score when using the PBL method as opposed to the LBC method. When looking at the PBL method alone, little difference was observed across the universities; however, when looking at the LBC method, more variation was observed across the universities, as indicated by the profile plot. The two-way interaction between gender and teaching method was not significant (p=0.41), whereas that between university and teaching method was significant (p=0.01).

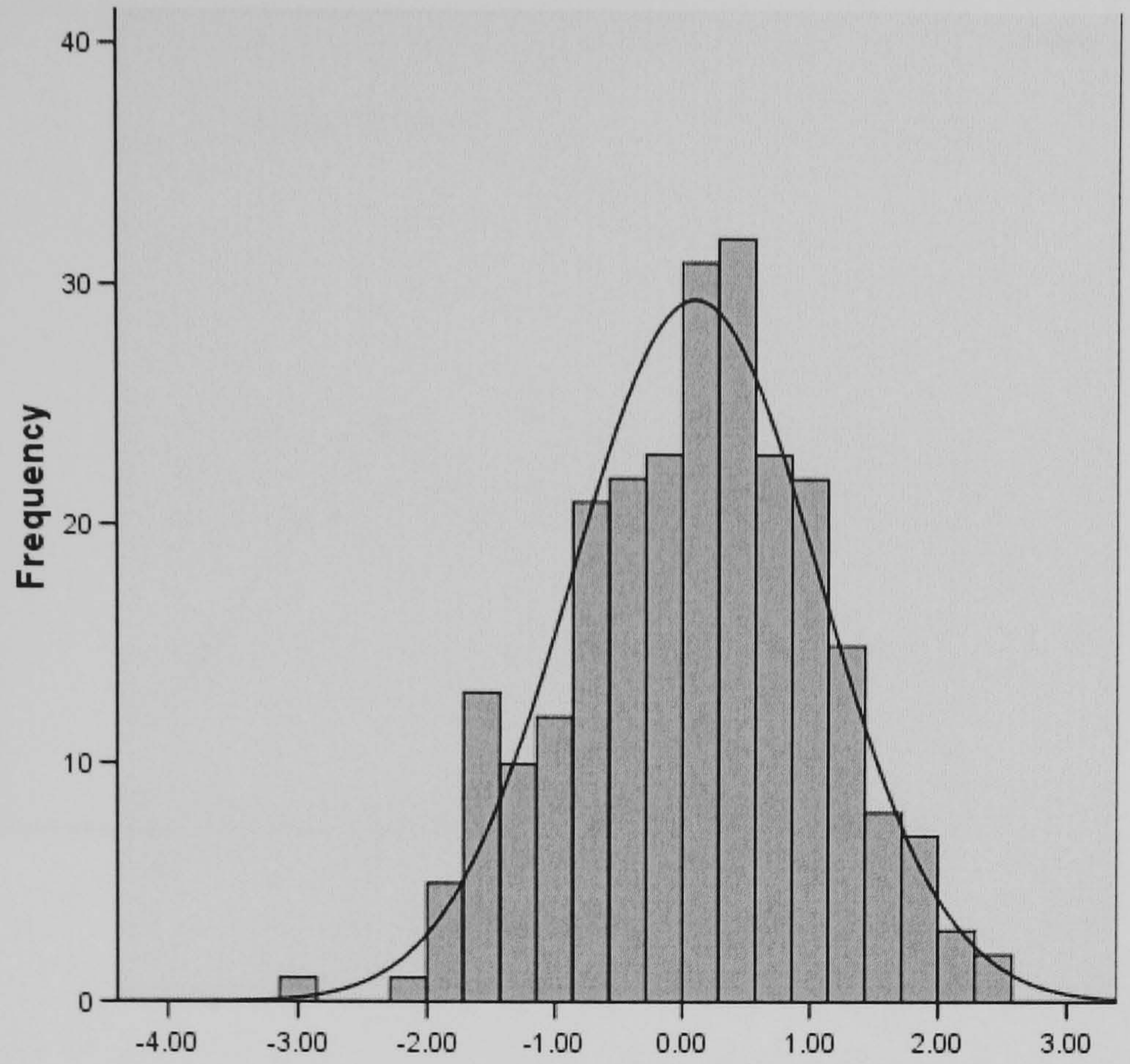
Figure 6.12 Profile plot of knowledge retention (reflection) across the universities



6.9 Motivation and intrinsic interest in learning

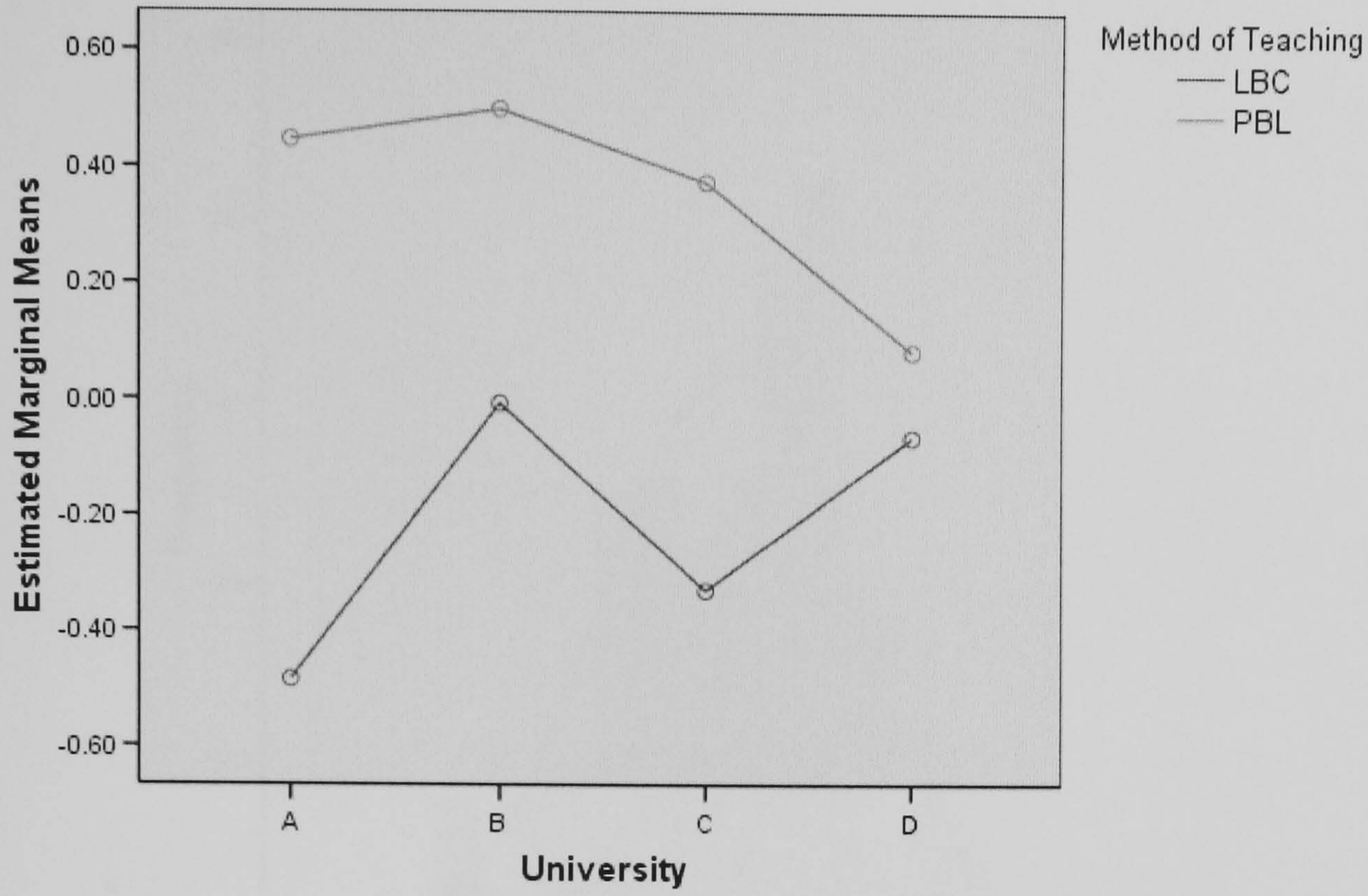
Clinical PBL students had a higher mean score than clinical LBC students with respect to *motivation and intrinsic interest in learning*: the mean score for clinical PBL students was 0.40, while that for clinical LBC students was -0.19. The mean difference was significant (t=-5.02, p=0.01), and the effect size was -0.63, with a standard error of 0.13. Thus clinical PBL students achieved a significantly higher score on *motivation and intrinsic interest in learning* than clinical LBC students. In fact, for each of the items under *motivation*, clinical PBL students achieved higher scores than clinical LBC students. A histogram of *motivation and intrinsic interest in learning* is shown in figure 6.13.

Figure 6.13 Motivation for clinical students



GLM univariate analysis on *motivation and intrinsic interest in learning* indicates that the main factors of gender and university were not significant, with p-values of 0.66 and 0.24 respectively; whereas that of teaching method was significant (p=0.01). The profile plot across the universities (figure 6.14) indicates that students in all four universities achieved a higher score when using the PBL method rather than the LBC method; this difference in teaching method was more noticeable for some universities than others, as indicated by the profile plot. The two-way interactions between gender and teaching method and between university and teaching method were not significant, having p-values of 0.99 and 0.20 respectively.

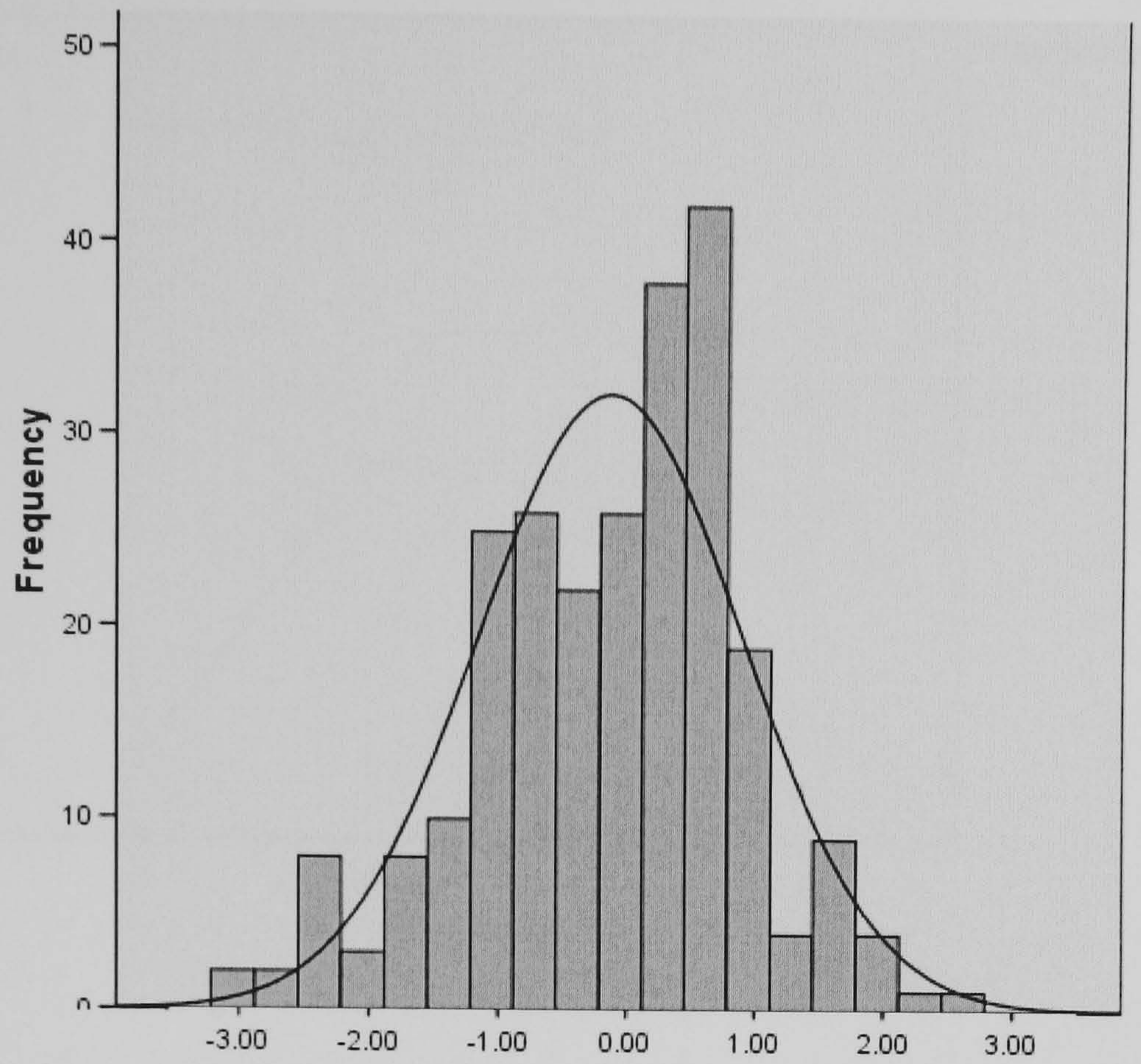
Figure 6.14 Profile plot of motivation across the universities



6.10 Self-directed skills

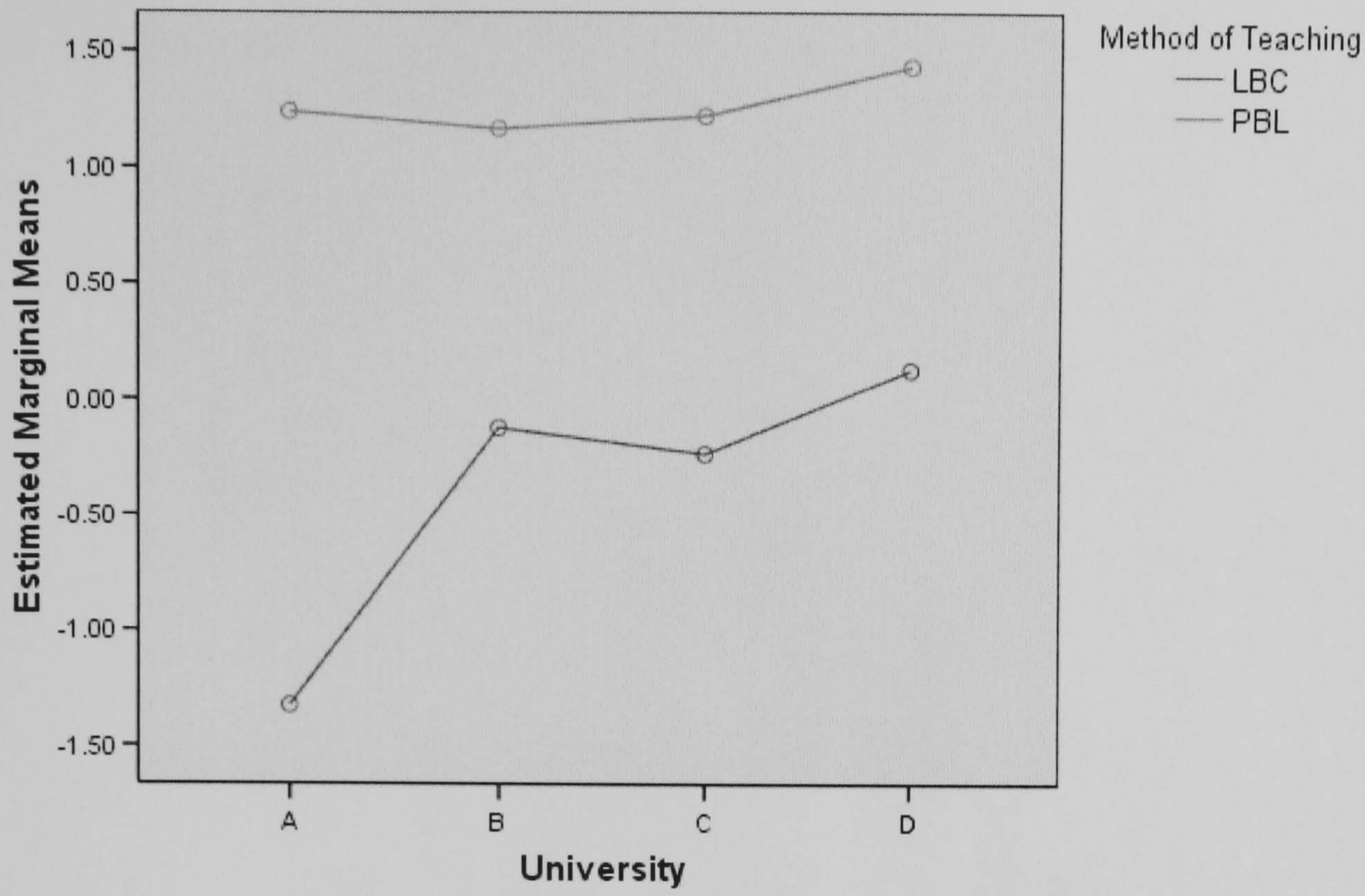
Clinical PBL students had a higher mean score (1.23) than clinical LBC students (-0.39) on *self-directed skills*, with a significant mean difference (t=-20.08, p=0.01); the effect size was 2.54 with a standard error of 0.17. In fact, for all the eight categories under *self-directed skills*, clinical PBL students achieved significantly higher scores than clinical LBC students. A histogram of *self-directed skills* is shown in figure 6.15.

Figure 6.15 Self-directed skills for clinical students



GLM univariate analysis on *self-directed skills* indicates that the main factor of gender was not significant (p=0.79), whereas the main factors of teaching method and university were significant, with p-values of 0.01 and 0.01 respectively. The profile plot across universities (figure 6.16) indicates that students in all four universities achieved a higher score when using the PBL method than when using the LBC method. The two-way interaction between gender and teaching method was not significant (p=0.35), whereas that between university and teaching method was (p=0.01). When looking at the PBL method alone, the difference across universities was very small; however, this was not the case when the profile plot for the LBC method across the universities was examined. As aforementioned, this could be due to the unique approaches of tutors when lecturing. In addition, knowledge gained by experience may have more impact on students than knowledge gained from lectures.

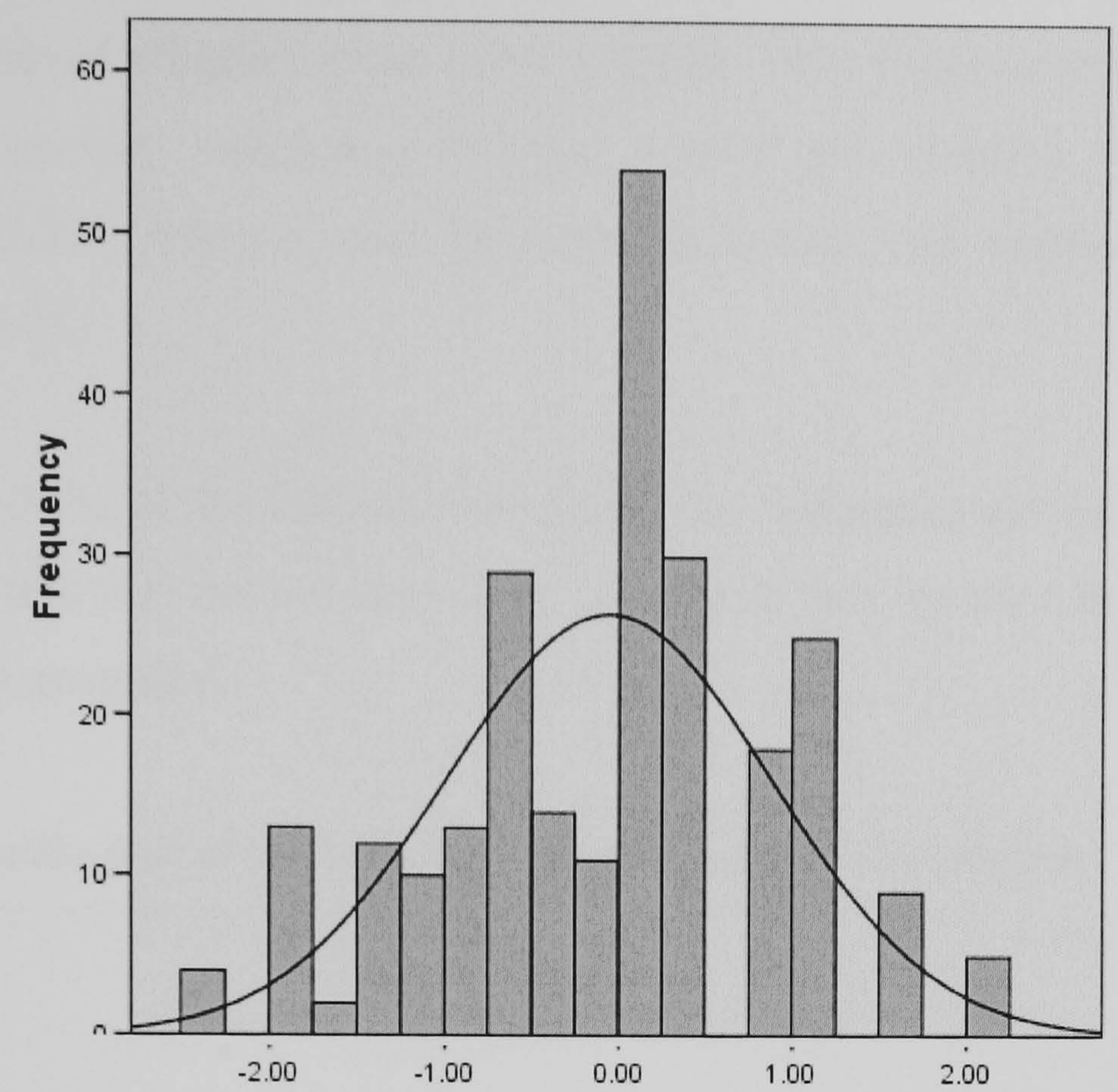
Figure 6.16 Profile plot of self-directed skills across the universities



6.11 Level of preparation

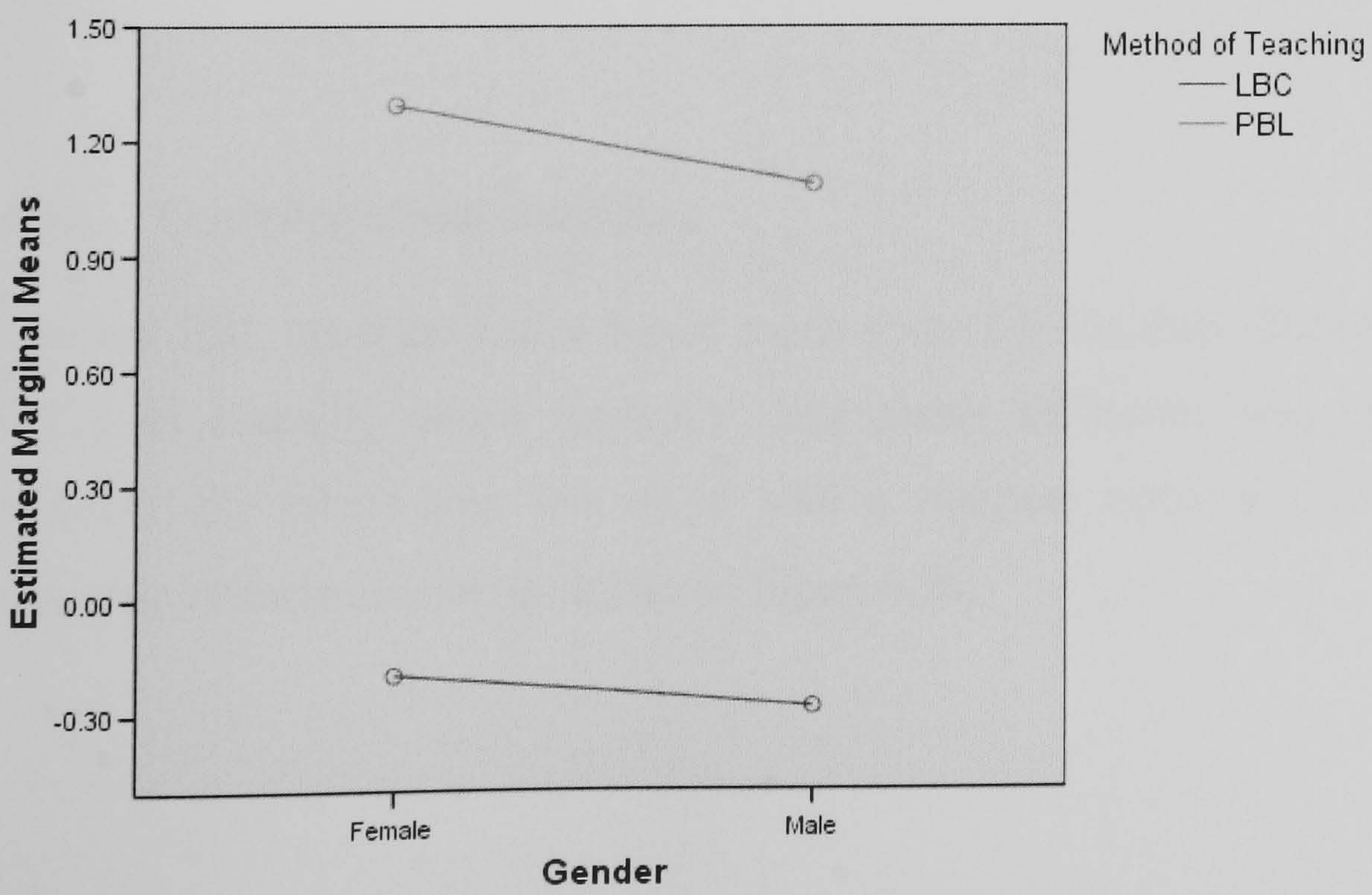
Clinical PBL students had a higher mean score (1.17) than clinical LBC students (-0.25) on *level of preparation*. The mean difference was significant (t=-18.42, p=0.01); the effect size was 2.33, with a standard error of 0.16. Thus clinical PBL students were, or felt, better prepared than clinical LBC students (whether preparing alone, with other students, regularly or irregularly). In fact, for all three of the categories under *level of preparation*, clinical PBL students achieved significantly higher scores than clinical LBC students. A histogram of *level of preparation* is shown in figure 6.17.

Figure 6.17 Level of preparation for clinical students



GLM univariate analysis on *level of preparation* indicates that the main factors of gender, teaching method and university have results that are significant, with p-values of 0.04, 0.01 and 0.01 respectively. The profile plot in figure 6.18 indicates that female students achieved a slightly higher score than male students on both LBC and PBL; thus female students had a higher *level of preparation* than male students on both the LBC and the PBL methods.

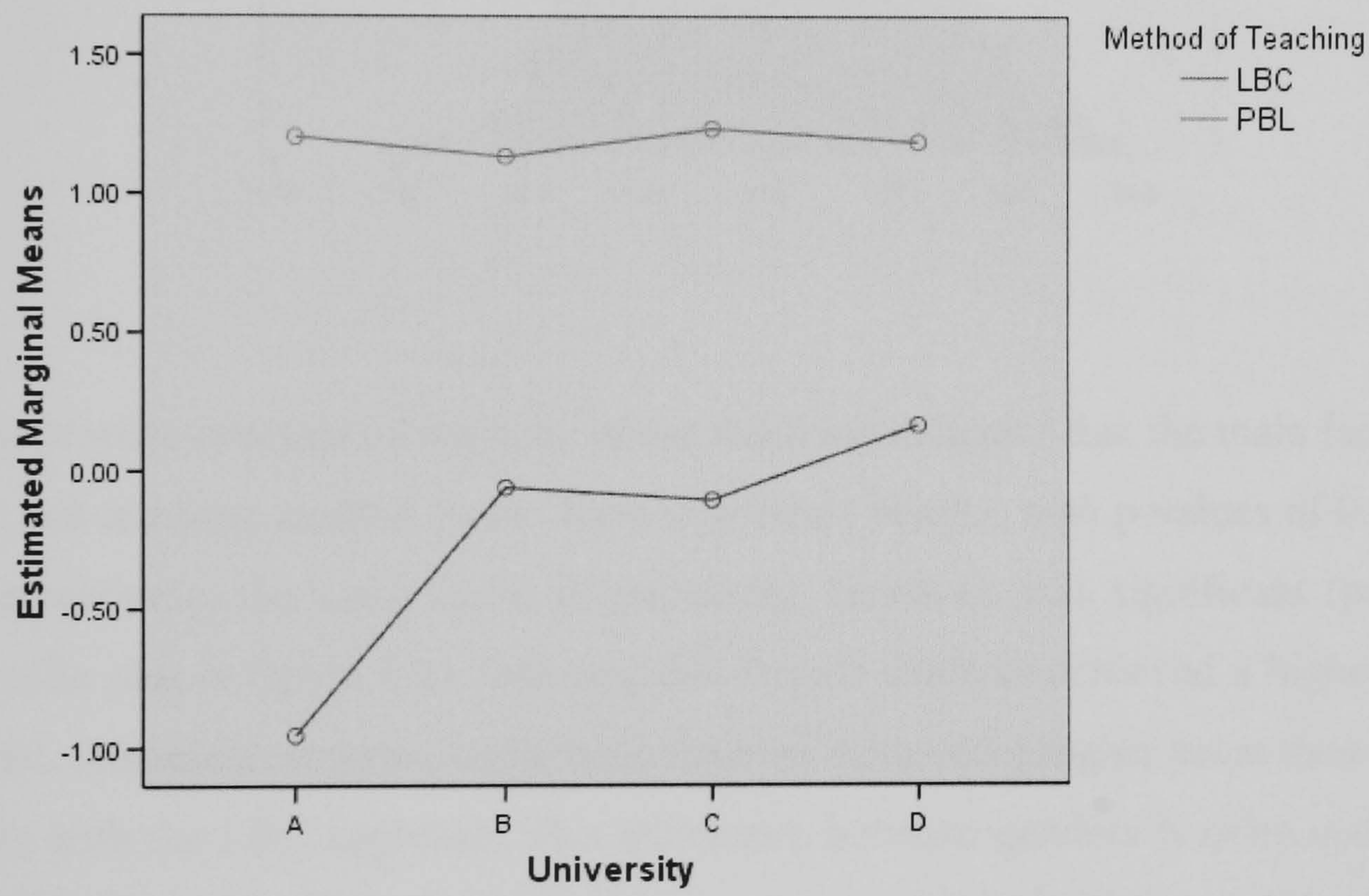
Figure 6.18 Profile plot of level of preparation across gender



The profile plot across the universities (figure 6.19) indicates that students in all four universities achieved a higher score when using the PBL method rather than the LBC method. The two-way interaction between gender and teaching method was not significant (p=0.39), whereas that between university and teaching method was significant (p=0.01).

Again, when looking at the PBL method alone, the difference across universities was very small, but this was not the case when the profile plot for the LBC method across universities was examined.

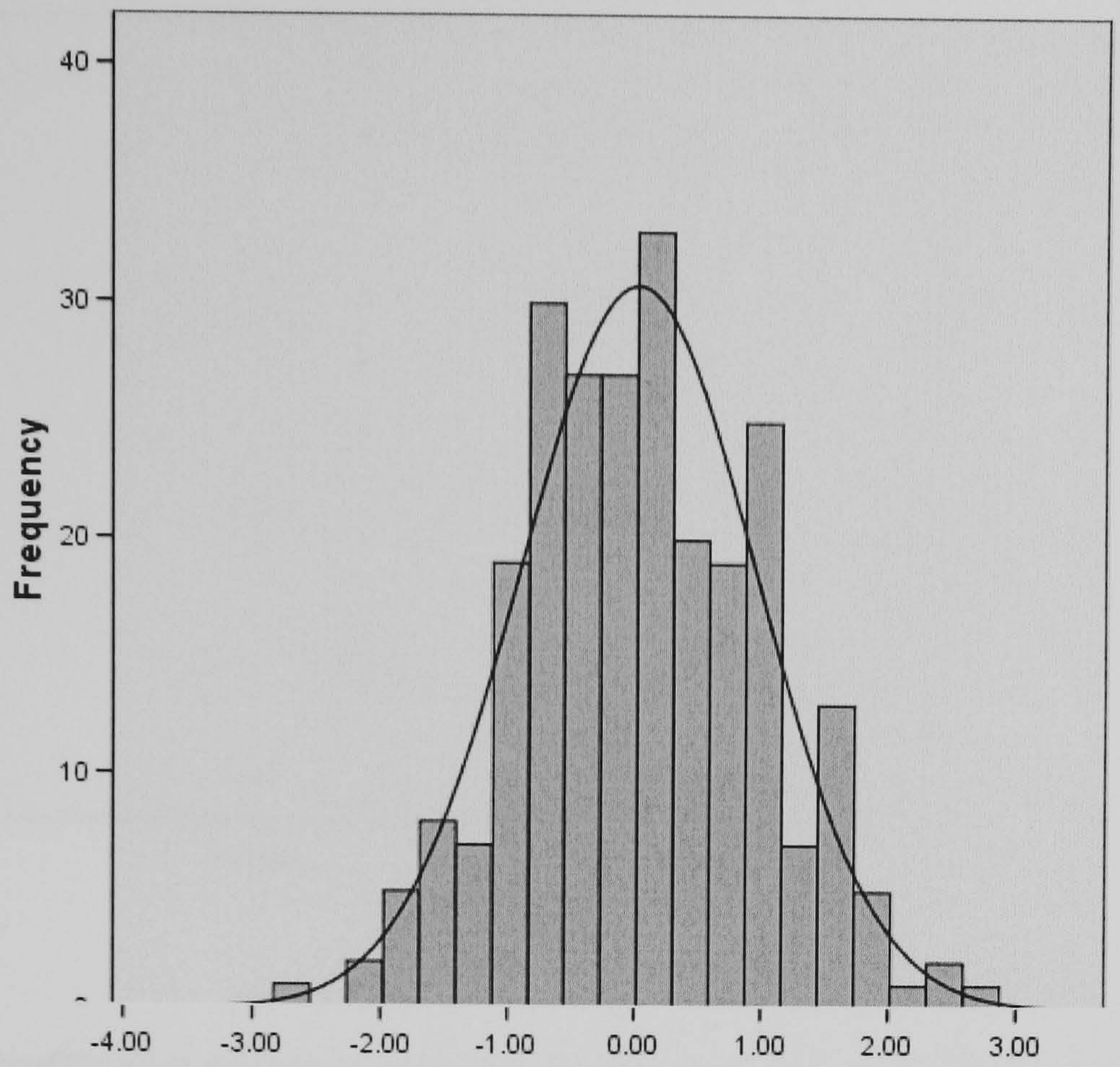
Figure 6.19 Profile plot of level of preparation across the universities



6.12 Learning about medicine

Clinical PBL students had a lower mean score (-0.46) than clinical LBC students (-0.11) on *learning about medicine*. The mean difference was significant (t=3.02, p=0.01); the effect size was -0.38 with a standard error of 0.13. A histogram of *learning about medicine* is shown in figure 6.20.

Figure 6.20 Learning about medicine for clinical students



GLM univariate analysis on *learning about medicine* indicates that the main factors of gender and teaching method do not have significant results, with p-values of 0.07 and 0.09 respectively; the main factor of university, however, was significant (p=0.01). The profile plot in figure 6.21 indicates that female students achieved a higher score with PBL than male students, while male students achieved a higher score than female students with the LBC approach. This difference between genders is more noticeable with LBC than PBL. The profile plot across the universities (figure 6.22) indicates that there is no clear pattern across the universities with respect to teaching methods. This is a clear departure from the results that have been seen so far, which show overall that clinical students generally do better across the universities on PBL than LBC. The two-way interactions between gender and teaching method and between university and teaching method were significant with p-values of 0.01 and 0.01 respectively.

Figure 6.21 **Profile plot of learning about medicine across gender**

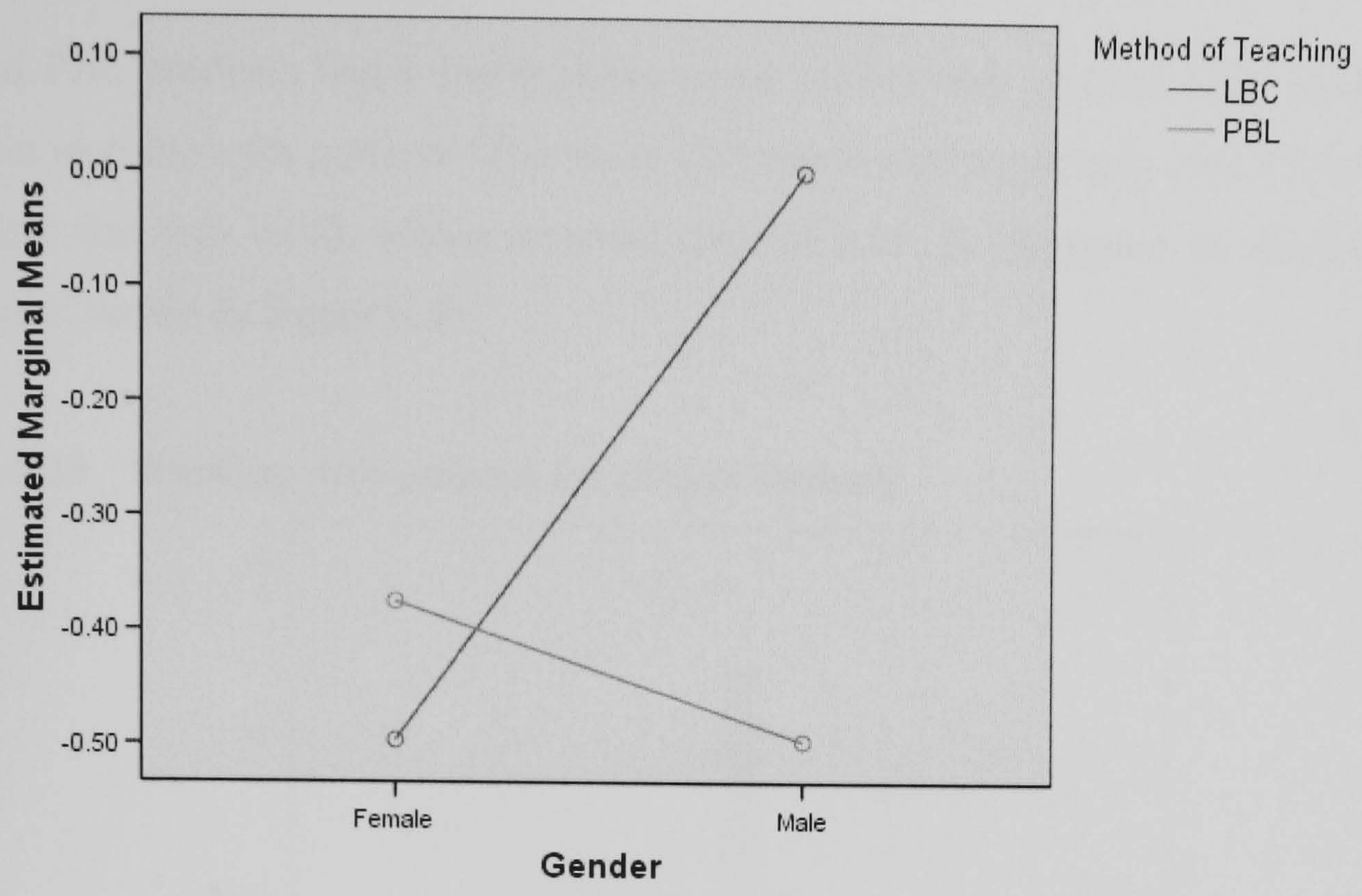
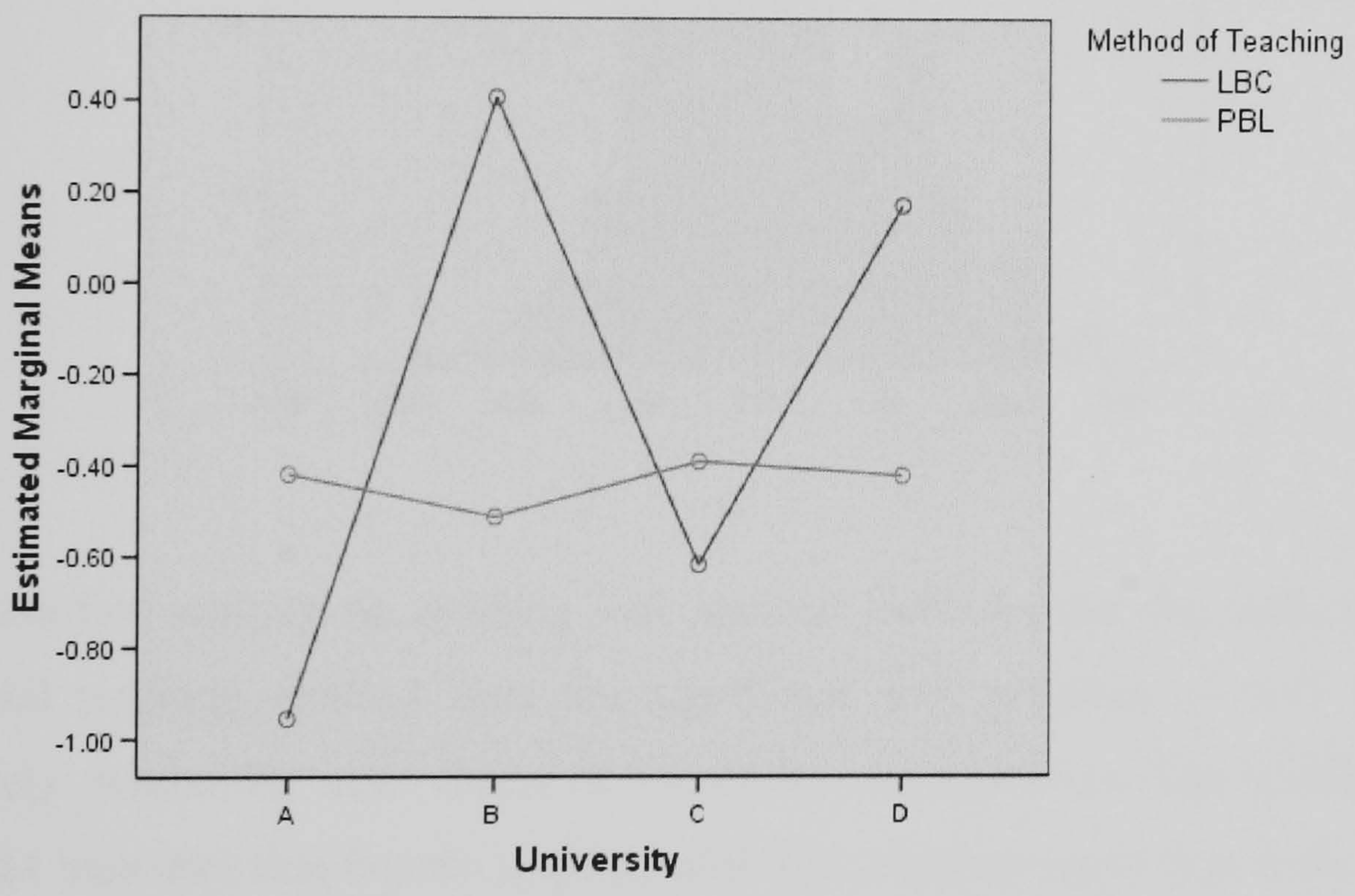


Figure 6.22 **Profile plot of learning about medicine across the universities**

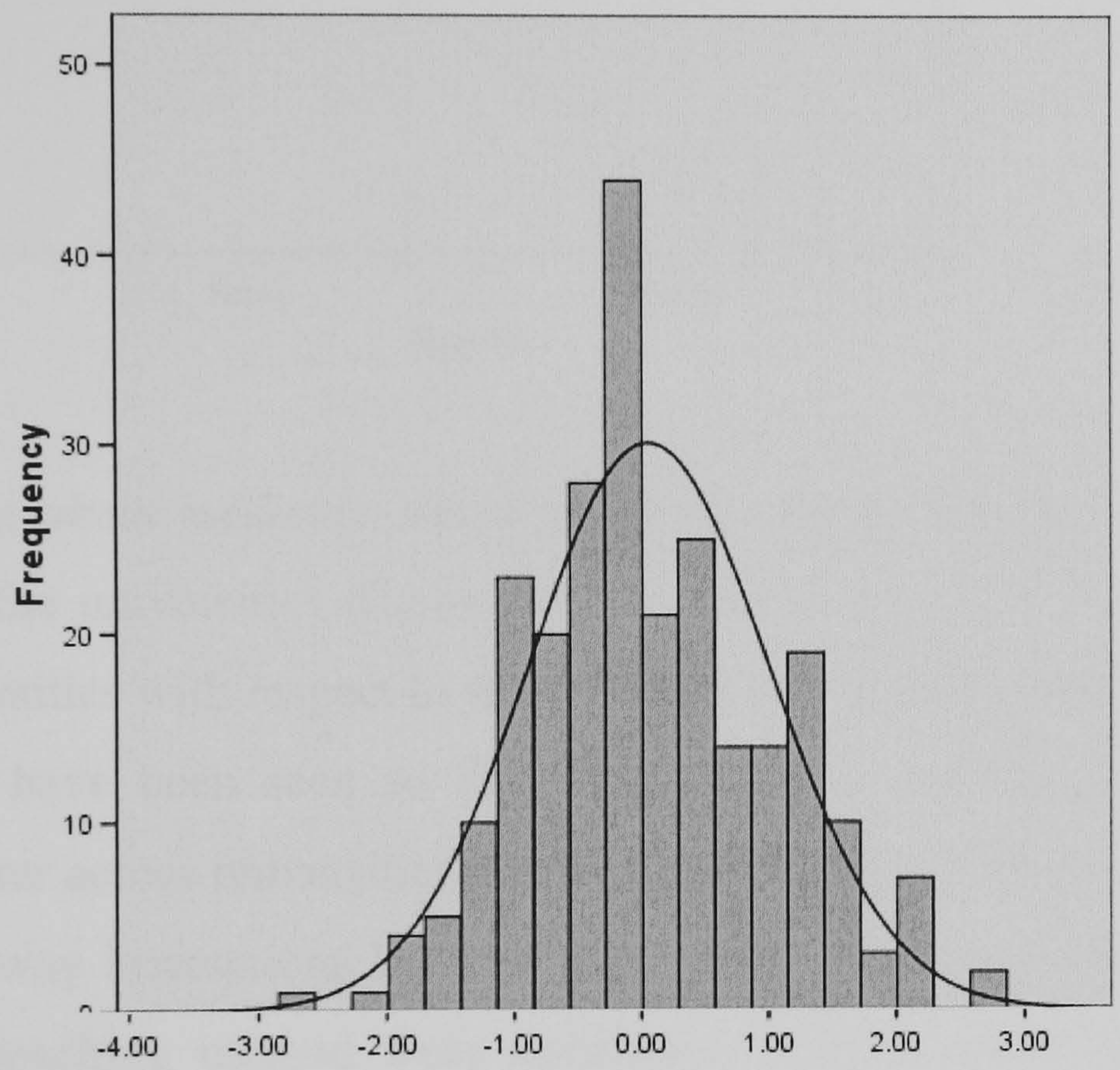


The profile plot of learning about medicine across gender shows that female students achieved a higher score with PBL than LBC, while for male students this was the inverse. The difference between teaching methods is more noticeable for male than for female students, which may be because female students are more willing to learn about medicine irrespective of the method of teaching employed. This may in turn be influenced by the female students' maternal instinct.

6.13 Working with patients

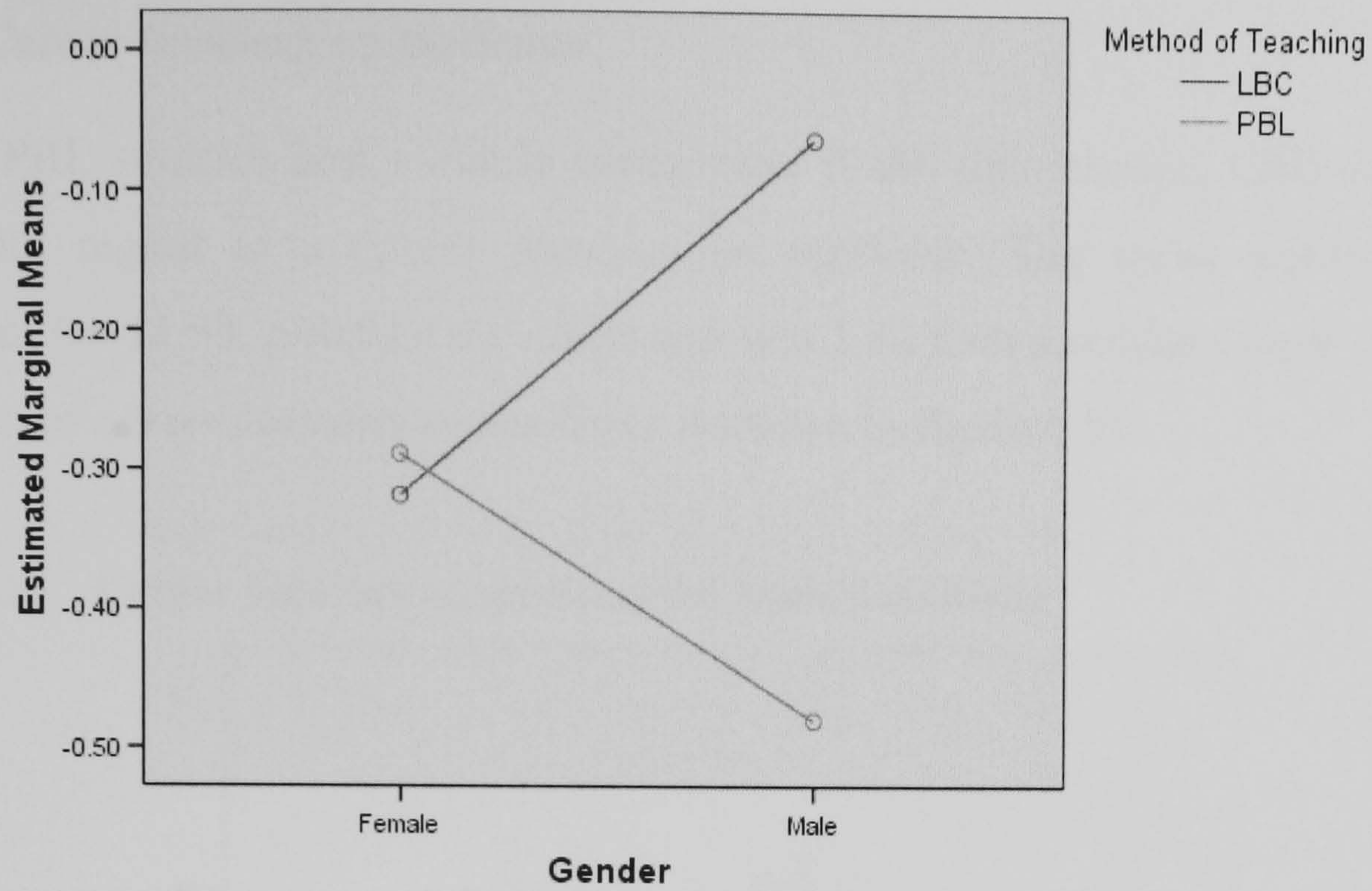
Clinical PBL students had a lower mean score (-0.42) than clinical LBC students (-0.05) on *working with patients*. The mean difference was significant (t=3.15, p=0.01); the effect size was -0.40, with a standard error of 0.13. A histogram of *working with patients* is shown in figure 6.23.

Figure 6.23 Working with patients for clinical students



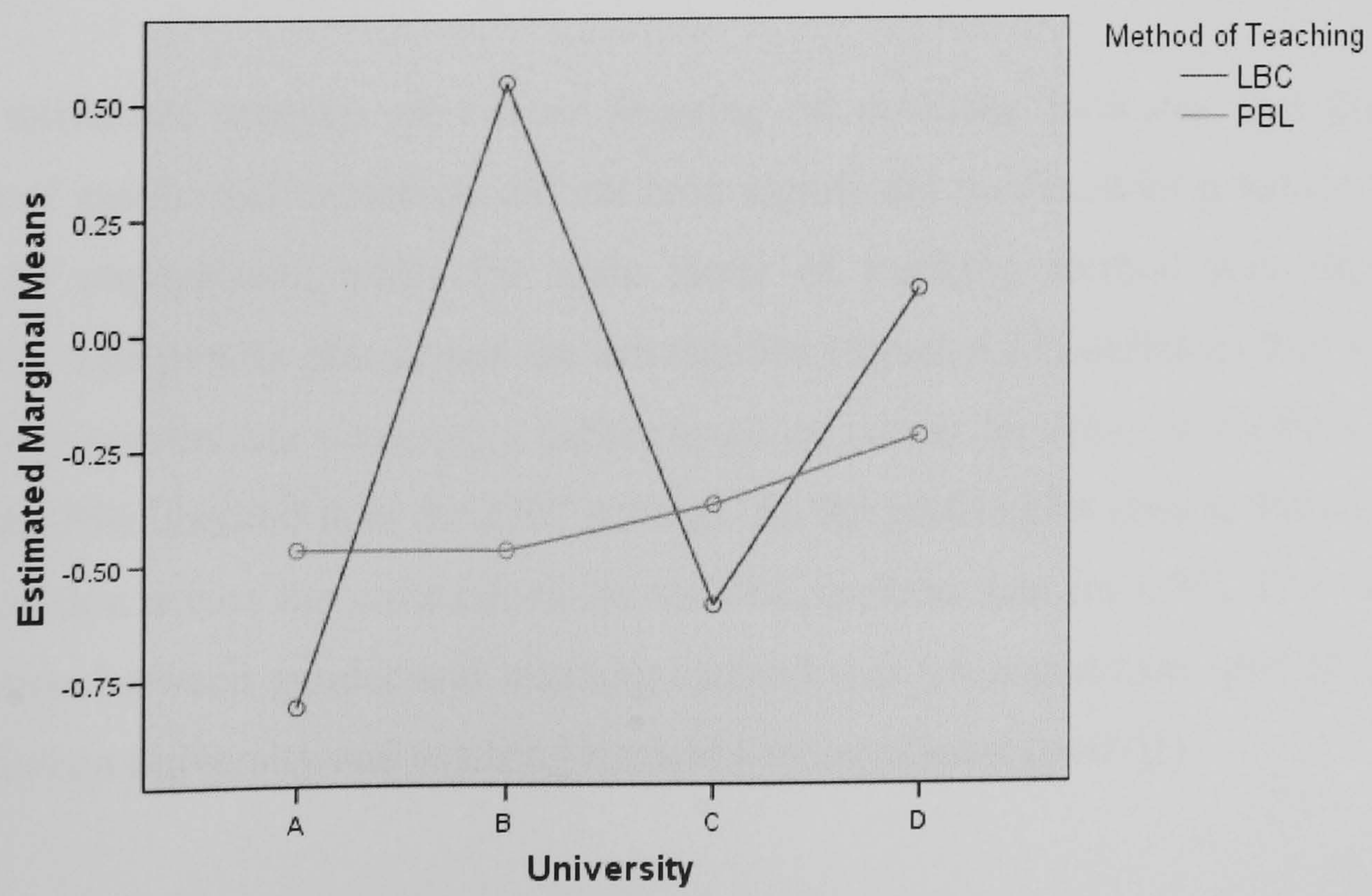
GLM univariate analysis on *working with patients* indicates that the main factors of gender and teaching method were not significant with p-values of 0.77 and 0.09 respectively, whilst the main factor of university was (p=0.01). The profile plot in figure 6.24 indicates that female students achieved a higher score than male students with PBL, while male students achieved a higher score than female students with LBC.

Figure 6.24 Profile plot of working with patients across gender



As with *learning about medicine*, discussed above, the profile plot of *working with patients* across the universities (figure 6.25) indicates that there is no clear pattern across the universities with respect to teaching method. This is a clear departure from the results that have been seen so far, which show overall that clinical students generally do better across universities on PBL than LBC (with the exception of figure 6.22). The two-way interactions between gender and teaching method and between university and teaching method were significant, with p-values of 0.04 and 0.01 respectively.

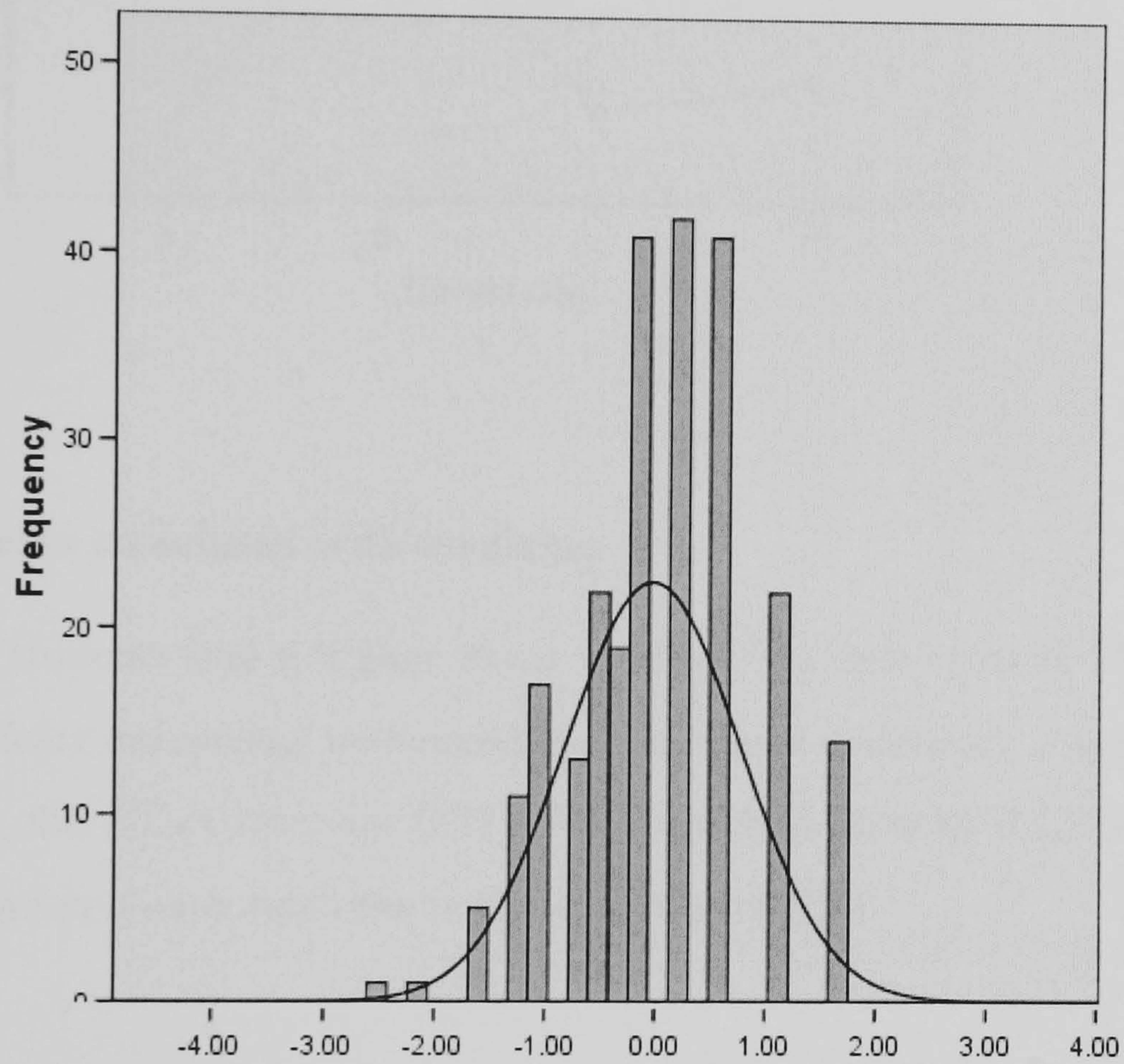
Figure 6.25 Profile plot of working with patients across the universities



6.14 Career focusing on medicine

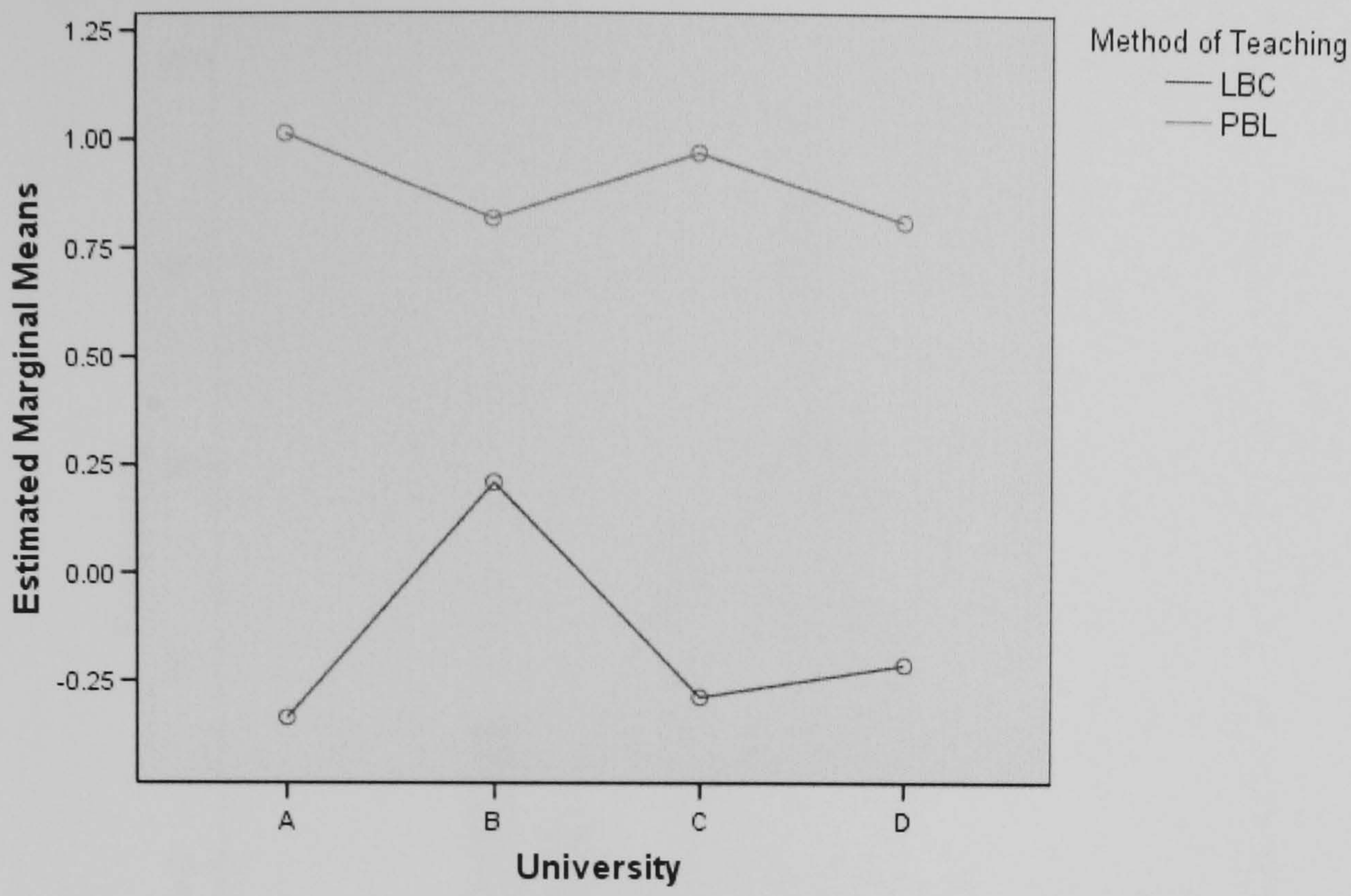
Clinical PBL students had a higher mean score (0.89) than clinical LBC students (-0.08) with regard to a *career focusing on medicine*. The mean difference was significant (t=-11.95, p=0.01); the effect size was 1.52 with a standard error of 0.14. A histogram of *career focusing on medicine* is shown in figure 6.26.

Figure 6.26 Career focusing on medicine for clinical students



GLM univariate analysis on *career focusing on medicine* indicates that the main factors of gender and university did not have significant results, with p-values of 0.76 and 0.14 respectively, while the main factor of teaching method was significant (p=0.01). The profile plot across the universities (figure 6.27) indicates that students in all four universities achieved a higher score on *career focusing on medicine* when using the PBL method than the LBC method. As the profile plot shows, there is much less variation across the universities for the PBL method than for LBC. The two-way interaction between gender and teaching method was not significant (p=0.28), while that between university and teaching method was significant (p=0.01).

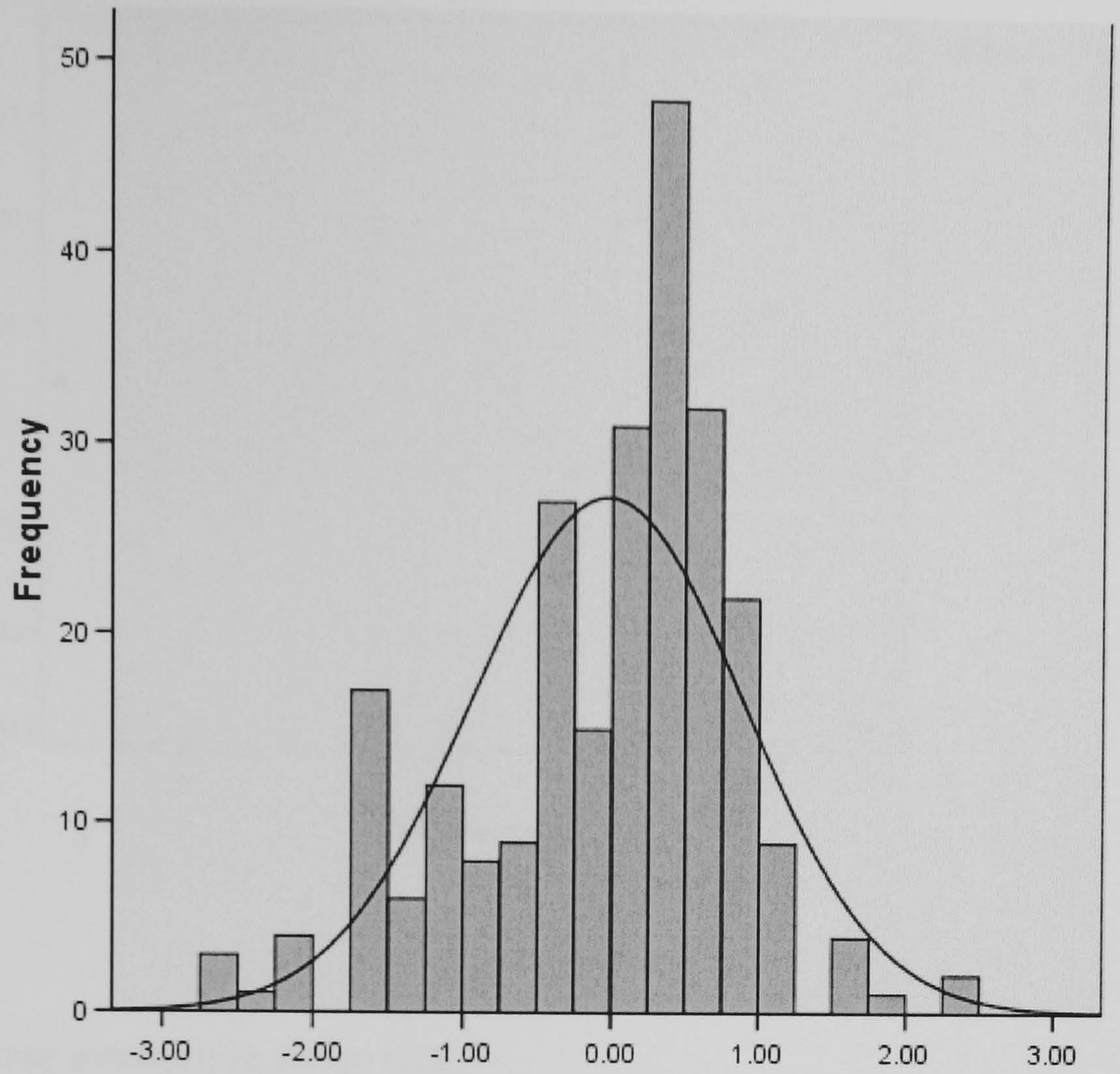
Figure 6.27 Profile plot of career focusing on medicine across the universities



6.15 Problems associated with medicine

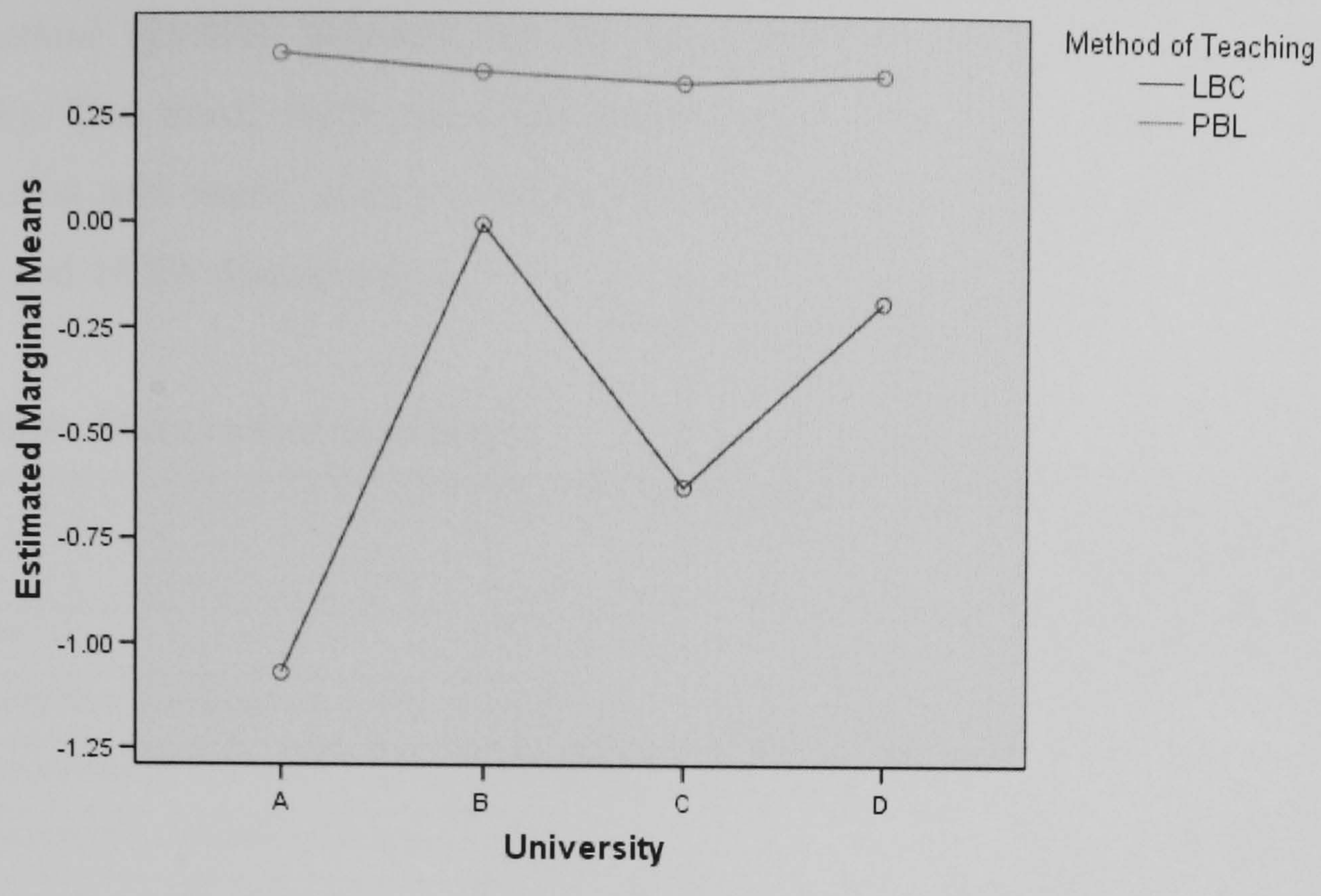
Clinical PBL students had a higher mean score (0.36) than clinical LBC students (-0.40) on *problems associated with medicine*. The mean difference was significant (t=-7.22, p=0.01); the effect size was 0.91 with a standard error of 0.13. A histogram of *problems associated with medicine* is shown in figure 6.28.

Figure 6.28 Problems associated with medicine for clinical students



GLM univariate analysis on *problems associated with medicine* indicates that the main factor of gender was not significant (p=0.66), while the main factors of teaching method and university were significant (p-values of 0.01 for both). The profile plot across the universities (figure 6.29) indicates that a clear pattern: in all four universities, students taught using PBL achieved a higher score than students taught using LBC. The two-way interaction between gender and teaching method was not significant (p=0.53), whereas the two-way interaction between university and teaching method was significant (p=0.01). For clinical students, the PBL method was better than the LBC method, shown by the higher profile plot for. Furthermore, there was much less variation across the universities for PBL than for LBC.

Figure 6.29 Profile plot of problem associated with medicine across the universities



6.16 Course evaluation form (CEF)

6.16.1 HGU evaluation, unit format and amount of work

Nearly 50% of clinical students said they studied HGU by LBC methods, and the remaining 50% said they studied it by PBL. Clinical students were also asked what percentage of the entire course they think should use their specified methods. To summarize the findings, 41% of clinical LBC students said that they would prefer their education to use LBC; the corresponding percentage for clinical PBL students was 47%. This was found to be significantly different, with a p-value of 0.02. However, the effect size was just 0.30, with a standard error of 0.13.

The main factors considered by students when deciding what percentage of their education should be taught using either LBC or PBL are shown in table 6.10. According to clinical PBL students, *the enjoyment of the method* was the most important factor considered (26.0%) followed by *the importance of the method to their professional practice* (24.3%). *The volume of information* and *the independence of learning* each gained 17.7% of the vote. The least important factor was *the interaction with peers* (14.4%).

Similarly, for clinical LBC students, the most important factor was *the enjoyment of the method* (28.4%) followed by *the importance to their professional practice* (20.7%). The third, forth and fifth factors were *the volume of information, the interaction with peers*, and *the independence of learning*, with percentages of 19.5%, 17.2% and 14.2% respectively.

Table 6.10 Main factors considered

	Method of Teaching	
	LBC	PBL
Factors	Percent	Percent
The enjoyment that I had using this method	28.4	26.0
The importance of this method to my professional practice	20.7	24.3
The volume of information I learned	19.5	17.7
The interaction with my peers	17.2	14.4
The independence of learning	14.2	17.6

Students' learning expectations with regard to their current learning method (LBC or PBL) are shown below in table 6.11. Even though there were slight variations in terms of percentages, no significant association was observed between teaching method and learning expectations. The Pearson Chi-Squared statistic was 5.75, with a p-value of 0.22.

Table 6.11 Learning expectations

			During the past three class sessions, I learned:					
			A lot more than I expected	Somewhat more than I expected	About as much as I expected	Somewhat less than I expected	Much less than I expected	Total
Method of Teaching	LBC	Count	32	34	26	24	8	124
		% within Method of Teaching	25.8%	27.4%	21.0%	19.4%	6.5%	100.0%
	PBL	Count	22	27	39	25	11	124
		% within Method of Teaching	17.7%	21.8%	31.5%	20.2%	8.9%	100.0%
Total		Count	54	61	65	49	19	248
		% within Method of Teaching	21.8%	24.6%	26.2%	19.8%	7.7%	100.0%

ChiSq=5.75, df=4, p=0.22

Concerning the format used in classes, 40.2% of the clinical LBC students said they would like to experience LBC again; the corresponding percentage from the clinical PBL students was lower, at 25%. While 18.8% of the clinical LBC students would prefer not to experience LBC again, a higher percentage (27.6%) of the clinical PBL students would prefer not to experience the PBL format again. Even though there are variations in these percentages, no significant association was observed. The Pearson Chi-Squared statistic was 6.65 with a p-value of 0.08. Responses regarding format are shown in table 6.12.

Table 6.12 Format used in classes

			The format used in the past three classes is one that I would:				
			Like to experience again	Like to experience again if these minor changes were made	Like to experience again if major changes were made:	Prefer not to experience again	Total
Method of Teaching	LBC	Count	47	23	25	22	117
		% within Method of Teaching	40.2%	19.7%	21.4%	18.8%	100.0%
	PBL	Count	29	25	30	32	116
		% within Method of Teaching	25.0%	21.6%	25.9%	27.6%	100.0%
Total		Count	76	48	55	54	233
		% within Method of Teaching	32.6%	20.6%	23.6%	23.2%	100.0%

ChiSq=6.65, df=3, p=0.08

With regard to the amount of work undertaken, 39.1% of the clinical LBC students said it was more than they were used to and intolerable, whilst the corresponding percentage from clinical PBL students was only 23.4%. For 14.8% of the clinical LBC students, the amount of work was more than they were used to but tolerable; the corresponding percentage from the clinical PBL students was higher (24.2%). A significant association was observed between the teaching method (LBC or PBL) and the amount of work. The Pearson Chi-Squared statistic was 9.50, with a p-value of 0.02. Overall, pre-clinical LBC students found the workload higher than pre-clinical PBL students did (see table 6.13).

Table 6.13 Amount of work

			Compared to the work I have done for this class so far, the amount of work involved in the past three class sessions was:				Total
			More than I am used to and intolerable	More than I am use to but tolerable	About same as I am used to	Not as much as I am used to	
Method of Teaching	LBC	Count	50	19	25	34	128
		% within Method of Teaching	39.1%	14.8%	19.5%	26.6%	100.0%
	PBL	Count	29	30	34	31	124
		% within Method of Teaching	23.4%	24.2%	27.4%	25.0%	100.0%
Total		Count	79	49	59	65	252
		% within Method of Teaching	31.3%	19.4%	23.4%	25.8%	100.0%

ChiSq=9.50, df=3, p=0.02

6.16.2 Small-group experience

Nineteen percent of clinical LBC students were aware of the activities of at least one other small group, whereas only 4.8% of the clinical PBL students were aware of another small group's activities (see table 6.14). There was significant association between the teaching method (LBC or PBL) and the awareness of the activities of other small groups. The Pearson Chi-Squared statistic was 11.95, with a p-value of 0.01. Thus a significantly higher percentage of the clinical LBC students were aware of the activities of at least one other small group compared to the clinical PBL students.

Table 6.14 Small-group experience

			Were you aware of the activities of at least one of the other small group?		Total
			No	Yes	
Method of Teaching	**LBC**	Count	102	24	126
		% within Method of Teaching	81.0%	19.0%	100.0%
	PBL	Count	118	6	124
		% within Method of Teaching	95.2%	4.8%	100.0%
Total		Count	220	30	250
		% within Method of Teaching	88.0%	12.0%	100.0%

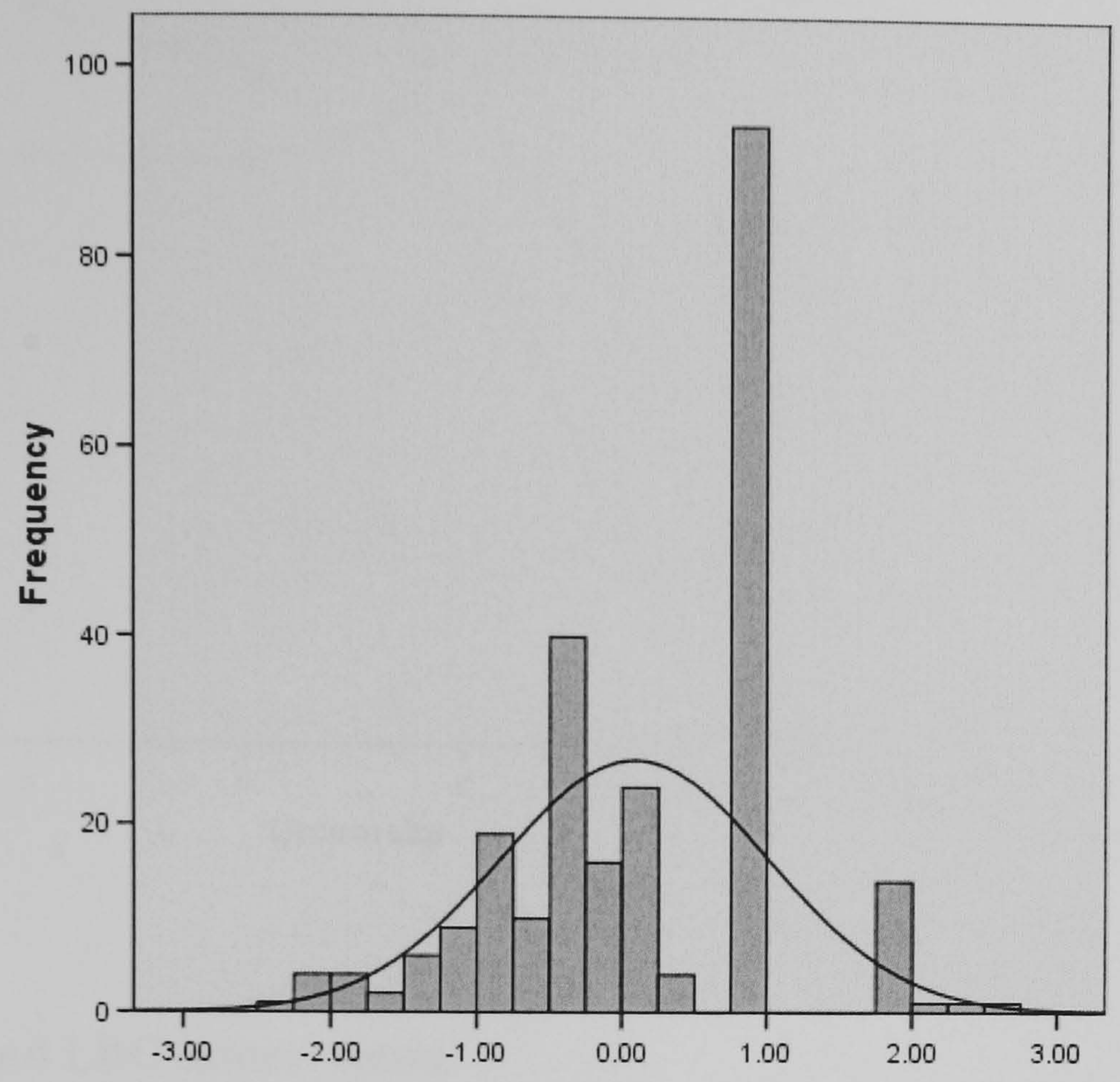
ChiSq=11.95, df=1, p=0.01

6.17 Resources of information

Clinical PBL students had a higher mean score (0.10) than clinical LBC students on *resources of information* (0.08). The mean difference was not significant (t=-0.19, p=0.85).

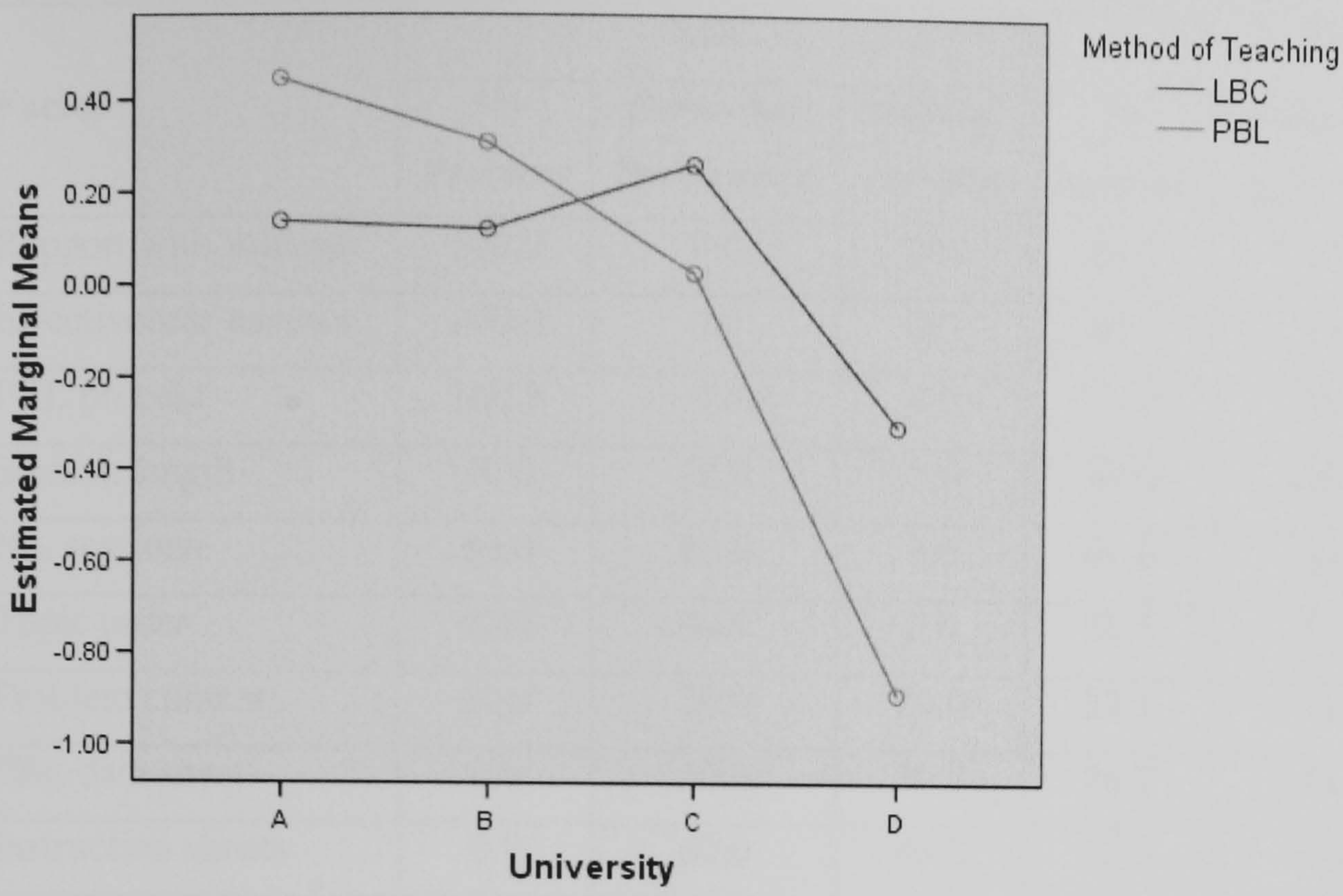
The eight categories under *resources of information* were: *lectures*, *tutorials*, *faculty outside class*, *other students outside class*, *textbooks*, *articles*, *labs* and *other*. A significant result was obtained on only two of these categories; namely *lectures* and *tutorials*. As regards *lectures*, clinical LBC students had a higher mean score (-0.11) than clinical PBL students (-0.55). These scores had a significant mean difference, with a p-value of 0.01, and an effect size of -0.54 with a standard error of 0.13. For *tutorials*, clinical LBC students had a lower mean score (0.17) than clinical PBL students (0.55); the mean difference was significant with a p-value of 0.01, and the effect size was 0.46 with a standard error of 0.13. This finding indicates that clinical LBC students preferred *lectures* to *tutorials* while clinical PBL students preferred *tutorials* to *lectures*. A histogram of *resources of information* is shown in figure 6.30. Overall, no significant result was observed between clinical LBC and PBL students on *resources of information*.

Figure 6.30 Resources of information for clinical students



GLM univariate analysis on *resources of information* indicates that the main factor of university did have a significant result, with a p-value of 0.01. The main factors of gender and teaching method were not significant, with p-values of 0.31 and 0.50 respectively. The profile plot across universities (figure 6.31) indicates that there was no clear pattern across all four universities, though students from Universities C and D achieved higher scores using LBC than PBL methods, as indicated by the profile plots. Students from Universities A and B achieved higher scores using PBL than LBC methods, as indicated by the profile plots. The two-way interaction between gender and teaching method was not significant (p=0.98), whereas that between university and teaching method was significant (p=0.05).

Figure 6.31 Profile plot of resources of information across the universities



6.18 PBL and LBC tutors' views

Information was solicited from tutors on the following factors: *rapport with students*, *effectiveness as tutor*, *PBL processes*, *session length* and number of *sessions*, *topic order*, *problem content*, *PBL data sheets*, *instruction sheets*, *student resources*, *learning issues*, *facilities* and *group size.* Tutors were asked to indicate how they found each factor by selecting *no problem*, *somewhat problematic*, or *definite problem* (see table 6.15). Taking *rapport with students* as an example, all LBC tutors said this was *no problem*; 86.7% of PBL tutors agreed. While 13.3% of PBL tutors said *rapport with students* was *somewhat problematic*; none said that it was a *definite problem.* No significant association was found between teaching method (LBC or PBL) and *rapport with students* or, in fact, for any of the factors. Whilst *PBL data sheets* were *somewhat problematic* to 50% of LBC tutors, and a *definite problem* to the other 50%. 46.6% of PBL tutors found them *somewhat problematic*, whereas 26.7% of them said it was a *definite problem.*

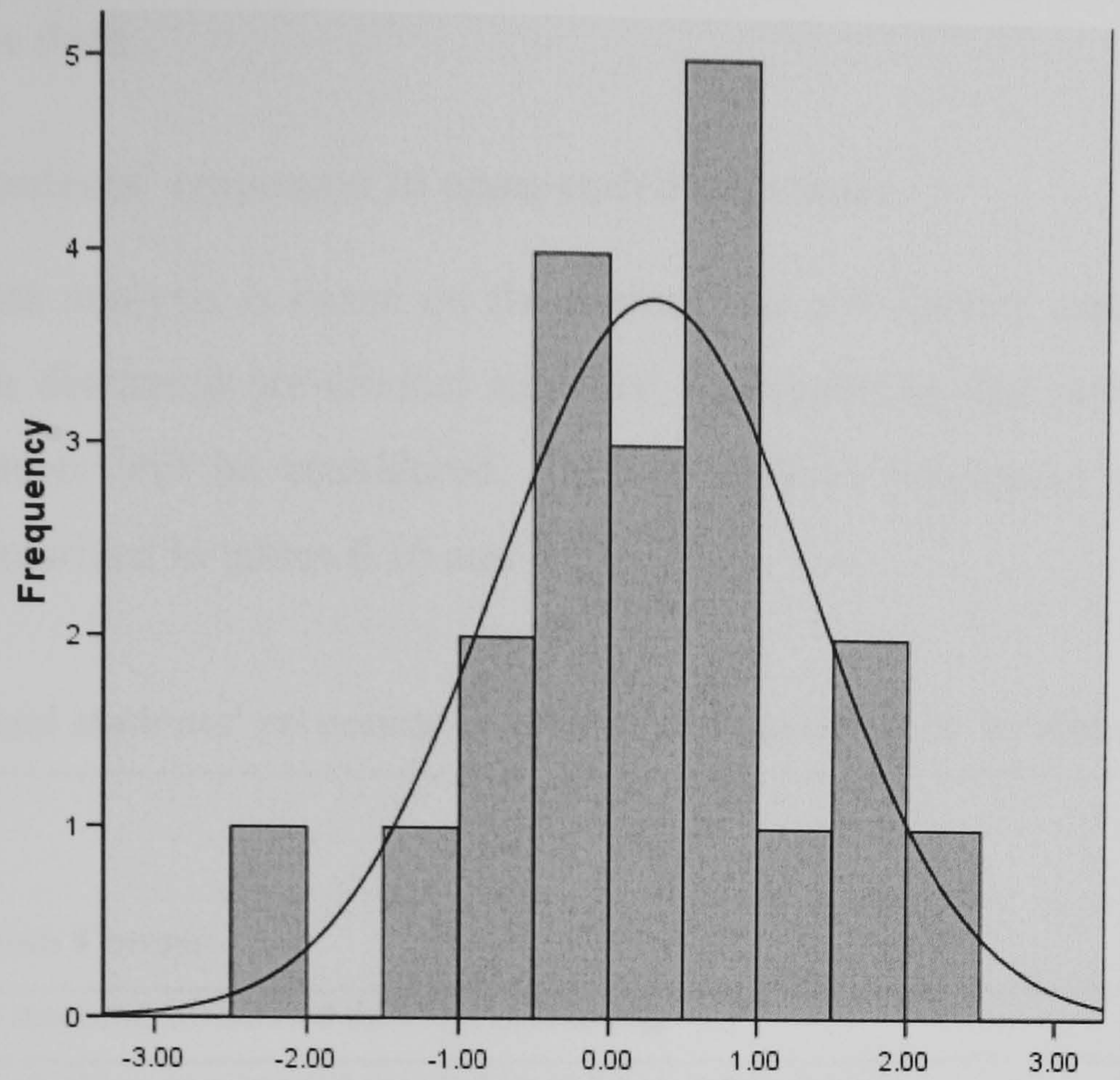
Table 6.15 LBC and PBL tutors' perception of learning method (n=17)

Factor	LBC			PBL		
	No Problem	Somewhat Problematic	Definite Problem	No Problem	Somewhat Problematic	Definite Problem
Rapport with students	100.0	0.0	0.0	86.7	13.3	0.0
Effectiveness as tutor	100.0	0.0	0.0	86.7	13.3	0.0
PBL process	100.0	0.0	0.0	71.4	28.6	0.0
Session length	80.0	20.0	0.0	60.0	40.0	0.0
No. sessions	80.0	20.0	0.0	60.0	40.0	0.0
Topic order	60.0	40.0	0.0	38.5	53.8	7.7
Problem content	60.0	20.0	20.0	23.1	53.8	23.1
PBL data sheets	0.0	50.0	50.0	26.7	46.6	26.7
Instruction sheets	0.0	60.0	40.0	33.3	46.7	20.0
Student resources	0.0	80.0	20.0	23.0	46.2	30.8
Learning issues	10.0	70.0	20.0	35.7	32.2	32.2
Facilities	60.0	0.0	40.0	60.0	26.7	13.3
Group Size	60.0	0.0	40.0	66.7	20.0	13.3

6.19 Tutors' perception of learning method

Clinical LBC tutors had a higher mean score than clinical PBL tutors on *tutors' perception of learning method.* The mean score from clinical LBC tutors was 0.85, whereas that from clinical PBL tutors was 0.06; the mean difference was not significant (t=1.58, p=0.13). Of the fourteen categories under *tutors' perception of learning method,* clinical LBC tutors achieved higher scores than clinical PBL tutors on thirteen. A histogram of *tutors' perception of learning method* is shown in figure 6.32. Overall, the perception of tutors did not vary significantly.

Figure 6.32 Tutors' perception of learning method for clinical students



Tutors were also asked if they would consider being a PBL/LBC tutor again. Unfortunately, many tutors did not answer this question - only one response was obtained for this question, and this came from an LBC tutor who said yes.

GLM univariate analysis on *tutors' perception of learning method* indicates that the main factors of university and teaching method did not have significant results, having p-values of 0.09 and 0.37 respectively. The two-way interaction between university and teaching method was not significant, with p-values of 0.67.

6.20 Qualitative data

6.20.1 Clinical students' responses to open-ended questions

The qualitative data analysis is based on the themes and sub-themes mentioned in Chapter Five (5.20), which discussed pre-clinical students' responses. In this section, the responses from clinical students will be considered. Clinical students' responses to the open-ended questions are summarized in tables 6.16 and 6.17.

Table 6.16 Clinical students' responses to open-ended questions by treatment group

Major Themes and Sub Themes		Number of times mentioned LBC	PBL
Student's perception of learning	The teaching stimulated the student learning	3	13
	The teaching encouraged the student to be an active learner	9	12
	The teaching developed student competence	2	0
Total		**14**	**25**
Student's perception of tutors	The tutors were authoritarian	0	0
	The tutors provided constructive criticism	3	4
	The tutors had good communication skills	8	8
Total		**11**	**12**
Student's academic self-perceptions	The student was confident about passing the exam	18	24
	The student's problem solving skills were developed through this method	2	8
	The student found this experience useful for their career	21	10
Total		**41**	**42**
Student perception of atmosphere	The atmosphere made the student relaxed by using this method in the class	7	16
	The atmosphere helped the student to understand	26	5
	The student was able to ask questions whenever they want to	7	15
Total		**40**	**36**

Looking at the major themes, table 6.16 shows that clinical PBL students mentioned their *perception of learning* more times than clinical LBC students: PBL students mentioned it 25 times, whereas LBC students mentioned it 14 times.

There was no difference in opinion between the treatment groups with respect to whether tutors were authoritarian, provided constructive criticism, or had good communication skills. As a major theme, PBL students mentioned their *perception of tutors* 12 times compared to the 11 times that LBC students mentioned it.

There was no difference in opinion between the treatment groups with regard to the students' academic self-perceptions. Clinical LBC students mentioned their academic self-perception 41 times compared to the 42 times mentioned by clinical PBL students.

Finally, the last major theme, *student perception of atmosphere*, was mentioned 40 times by clinical LBC students and 36 times by clinical PBL students. There was no clear difference between the two treatment groups on this theme.

Looking at the sub-themes, the students' responses to the open-ended questions and their written comments echoed the quantitative findings: for example, 24 clinical PBL students said that they were *confident in passing exams*, compared to 18 clinical LBC students. This is in line with the quantitative results, as clinical PBL students achieved a higher mean score on exams than clinical LBC students. Similarly, clinical PBL students achieved a higher mean score on problem-solving skills than clinical LBC students. Again, the students' responses were in line with these quantitative results, as 8 clinical PBL students said that their problem-solving skills had been developed, while clinical LBC students mentioned this only twice. Finally, 21 clinical LBC students said that they found the experience useful for their career, compared to only 10 clinical PBL students.

On the other hand, 13 clinical PBL students said that *the teaching stimulated student learning*, while this was the case for only 3 clinical LBC students. This echoes the quantitative results, which show that clinical PBL students achieved a higher mean score on motivation than clinical LBC students.

16 clinical PBL students said that *the atmosphere made students relaxed*, while this was true for only 7 clinical LBC students. Furthermore, whilst 15 clinical PBL students said that they were *able to ask questions*, only 7 clinical LBC students agreed with this.

Table 6.17 Clinical students' responses to open-ended questions by treatment group/gender

Major themes and sub-themes		**Number of times mentioned**			
		LBC		**PBL**	
		Gender		**Gender**	
		F	**M**	**F**	**M**
Student's perception of learning	The teaching stimulated the student learning	3	0	9	4
	The teaching encouraged the student to be an active learner	2	7	8	4
	The teaching developed student competence	2	0	0	0
Total		**7**	**7**	**17**	**8**
Student's perception of tutors	The tutors were authoritarian	0	0	0	0
	The tutors provided constructive criticism	3	0	0	4
	The tutors had good communication skills	3	5	4	4
Total		**6**	**5**	**4**	**8**
Student's academic self-perceptions	The student was confident about passing the exam	11	7	8	16
	The student's problem-solving skills were developed through this method	0	2	0	8
	The student found this experience useful for their career	9	12	5	5
Total		**20**	**21**	**5**	**13**
Student's perception of atmosphere	The atmosphere made the student relaxed by using this method in the class	4	3	13	3
	The atmosphere helped the student to understand	14	12	0	5
	The student was able to ask questions whenever they wanted to	3	4	5	10
Total		**21**	**19**	**18**	**18**

6.20.2 Clinical tutors' responses to open-ended questions

This section will now look at the responses of clinical tutors to the open-ended questions, which are shown in table 6.18. On the whole, there were 9 mentionings by clinical PBL tutors, and 8 by clinical LBC tutors. Looking at the individual statements, clinical PBL tutors mentioned *understanding of the subject matter* twice, while clinical LBC tutors mentioned it just once. Clinical PBL tutors mentioned *commitment with respect to group functionality* 3 times, while clinical LBC tutors mentioned it 6 times. Clinical LBC tutors mentioned *confidence in learning method* just once, while clinical PBL tutors mentioned it 4 times. Overall, there is little difference between the treatment groups. This confirmed the quantitative results, as no difference was observed between the treatment groups on the tutors' perception of the learning method.

Table 6.18 Tutors' responses to open-ended questions by treatment group

Themes	Number of times mentioned	
	LBC	**PBL**
The tutor shows understanding of the subject matter	1	2
The tutor shows commitment with respect to group functionality	6	3
The tutor shows confidence in the learning method being used	1	4
The tutor shows capability of using their expert knowledge	0	0
Total	**8**	**9**

The breakdown of the statements with respect to gender within each treatment group does not reveal any differences between treatment groups (as shown in table 6.19).

Table 6.19 Tutors' responses to open-ended questions by treatment group / gender

Themes	Teaching Method			
	LBC		**PBL**	
	Gender		**Gender**	
	Female	**Male**	**Female**	**Male**
The tutor shows understanding of the subject matter	1	0	2	0
The tutor shows commitment with respect to group functionality	2	4	3	0
The tutor shows confident in the learning method being used	1	0	0	4
The tutor shows capability of using their expert knowledge	0	0	0	0
Total	**4**	**4**	**5**	**4**

6.21 Hypotheses revisited for clinical students

In Chapter Two, fourteen hypotheses were stated regarding learning and affective behavioural differences between Saudi undergraduate clinical medical students using PBL and those following a more traditional approach (LBC). These hypotheses were considered in turn.

Hypothesis 1: *It was hypothesized that students taught in PBL would have higher scores in examinations than students taught in a lecture-based format.* This hypothesis was not supported. The findings indicate that clinical PBL students achieved higher scores in human genetics examinations than clinical LBC students, with a mean value of 0.03 compared with -0.03. However, the result was not statistically significant (t=-0.48, p=0.63; see table 6.22).

Hypothesis 2: *It was hypothesized that students taught in PBL would have a better awareness of their genetics knowledge requirement than those taught in a lecture-based format.* This hypothesis was supported. The results indicate that clinical PBL students have a better awareness of their genetics knowledge requirement than clinical LBC students, with a mean value of 1.19 compared with -0.23. This was found to be statistically significant (t=19.50, p=0.01). The effect size was 2.46 (see table 6.22).

Hypothesis 3: *It was hypothesized that students taught in PBL would have better problem-solving and critical thinking skills than students taught in a lecture-based format.* This hypothesis was supported. The results indicate that clinical PBL students did have better problem-solving and critical thinking skills than clinical LBC students, with a mean value of 1.24 compared with -0.37. This was found to be statistically significant (t=-19.11, p=0.01), with an effect size of 2.43 (see table 6.22).

Hypothesis 4: *It was hypothesized that students taught in PBL would have a higher capacity of knowledge retention (reflection) than those taught in a lecture-based format.* This hypothesis was supported. Analysis of the data indicates that clinical PBL students did have a higher capacity of knowledge retention (reflection) than clinical LBC students, with a mean value of 1.25 compared with -0.40. This was found to be statistically significant (t=-20.12, p=0.01), with an effect size of 2.53 (see table 6.22).

Hypothesis 5: *It was hypothesized that students taught in PBL would have better motivation than those taught in a lecture-based format.* This hypothesis was also supported. Again, analysis of the data indicates that clinical PBL students did have better motivation than clinical LBC students, with a mean value of 0.40 compared with -0.19. This was found to be statistically significant (t=-5.02, p=0.01), with an effect size of 0.63 (see table 6.22).

Hypothesis 6: *It was hypothesized that students taught in PBL would have more confidence in conducting self-directed learning than those taught in a lecture-based format.* This hypothesis was supported. Analysis of the data indicates that clinical PBL students did have more confidence in conducting self-directed learning than clinical LBC students, with a mean value of 1.23 compared with -0.39. This was found to be statistically significant (t=-20.08, p=0.01), with an effect size of 2.54 (see table 6.22).

Hypothesis 7: *It was hypothesized that students taught in PBL would be generally more prepared for each session than those taught in a lecture-based format.* This hypothesis was supported. Analysis of the data indicates that clinical PBL students did have a higher level of preparation than clinical LBC students, with a mean value of 1.17 compared with -0.25. This was found to be statistically significant (t=-18.42, p=0.01), with an effect size of 2.33 (see table 6.22).

Hypothesis 8: *It was hypothesized that students taught in PBL would be less likely to be confused, frustrated or stressed when learning about medicine than students taught in a lecture-based format.* This hypothesis was not supported. On the contrary, clinical LBC students had a slightly higher mean score (-0.11) than clinical PBL students (-0.46). This was statistically significant (t=3.02, p=0.01); however, the effect size was just -0.38 (see table 6.22).

Hypothesis 9: *It was hypothesized that students taught in PBL would be less likely to be confused, frustrated or stressed when working with patients than students taught in a lecture-*

based format. As with hypothesis 8, this hypothesis was not supported. On the contrary, clinical LBC students had a slightly higher mean score (-0.05) than clinical PBL students (-0.42). This was statistically significant (t=3.15, p=0.01), although the effect size was just -0.40 (see table 6.22).

Hypothesis 10: *It was hypothesized that students taught in PBL would be less likely to be confused, frustrated or stressed regarding a career focusing on medicine than students taught in a lecture-based format.* This hypothesis was supported. Analysis of the data indicates that clinical PBL students did have lower levels of frustration, stress and confusion than clinical LBC students, with a mean value of 0.89 compared with -0.08. This was found to be statistically significant (t=-11.95, p=0.01), with an effect size of 1.52 (see table 6.22).

Hypothesis 11: *It was hypothesized that students taught in PBL would be less likely to be confused, frustrated or stressed regarding problems associated with medicine than students taught in a lecture-based format.* This hypothesis was supported. Analysis of the data indicates that clinical PBL students did have lower levels of frustration, stress and confusion regarding problems associated with medicine than clinical LBC students, with a mean value of 0.36 compared with -0.40. This was found to be statistically significant (t=-7.22, p=0.01), with an effect size of 0.91 (see table 6.22).

Hypothesis 12: *It was hypothesized that students taught in PBL would have a better learning experience than those taught in a lecture-based format.* This hypothesis was supported. Analysis of the data indicates that clinical PBL students did have a better learning experience than clinical LBC students, with a mean value of 1.21 compared with -0.23. This was found to be statistically significant (t=-20.12, p=0.01), with an effect size of 2.54 (see table 6.22).

Hypothesis 13: *It was hypothesized that students taught in PBL would be more competent in the use of resources available than students taught in a lecture-based format.* This hypothesis was not supported. Analysis of the data indicates that clinical PBL students did have a higher competence of using resources of information available than clinical LBC students, with a mean value of 0.10 compared with 0.08. This was, however, not statistically significant (t=-0.19, p=0.85; see table 6.22).

Hypothesis 14: *It was hypothesized that PBL tutors would have a higher opinion of PBL methods than LBC tutors* of LBC methods. This hypothesis was not supported. On the contrary, analysis of the data indicates that clinical LBC tutors had a higher perception of learning method than clinical PBL tutors, with a mean value of 0.85 compared with 0.06. This was not statistically significant, however ($t=1.58$, $p=0.13$) (see table 6.22).

6.22 Pre Data

As mentioned in chapter 5, some students switched from PBL to LBC and vice versa. It is therefore important to look at the pre data for clinical students to see how many moved. Table 6.20 shows the students group membership pre and post intervention and it shows that a few did change group.

Table 6.20 Number of students reporting membership of group

		Pre Intervention		
		LBC	PBL	Total
Post Intervention	LBC	113	14	127
	PBL	15	110	125
Total		128	124	252

The correlations between the pre and post measures are shown in table 6.21. They are all low and visual inspection of the scatter graphs showed satisfactuary relationships.

Regression analyses were then used to produce residuals for the post measures controlling for the pre measures. The residuals were used to calculate effect sizes, which are compared in table 6.22. The effect sizes were calculated with no control.

Table 6.21 Correlation coefficients (r) between pre and post data for all subscales for clinical students and tutors

Subscales	r
Fulfil knowledge requirement	0.11
Problem-solving and critical thinking skills	0.15*
Knowledge retention (reflection)	0.14*
Motivation	0.03
Self-directed skills	0.09
Level of preparation	0.13
Learning about medicine	0.08
Working with patients	0.06
Career focusing on medicine	0.03
Problems associated with medicine	0.00
Learning experience	0.18**
Resources of information	0.09
Tutors' perception of learning method	-0.18

** Sig at 1%; * Sig at

Table 6.22 Comparing effect sizes from residuals and random assignment

	From Residuals		Random Assignment	
Subscales	Effect size	Std Error	Effect size	Std Error
Exam test total	-	-	0.06	0.13
Fulfil knowledge requirement	2.40	0.17	2.46	0.17
Problem-solving and critical thinking skills	2.30	0.17	2.43	0.17
Knowledge retention (reflection)	2.37	0.17	2.53	0.17
Motivation	0.63	0.14	0.63	0.13
Self-directed skills	2.41	0.17	2.54	0.17
Level of preparation	2.22	0.17	2.33	0.16
Learning about medicine	-0.42	0.13	-0.38	0.13
Working with patients	-0.42	0.13	-0.40	0.13
Career focusing on medicine	1.48	0.15	1.52	0.14
Problems associated with medicine	0.88	0.14	0.91	0.13
Learning experience	2.22	0.17	2.54	0.17
Resources of information	0.03	0.13	0.02	0.13
Tutors' perception of learning method	-0.78	0.48	-0.79	0.50

As with the pre-clinical analyses, the effect sizes were very similar with and without control of some degrees in the magnitude after regression. These degrees were very small however, and therefore the conclusion reached earlier remains the same. For the pre data, see Appendix E.

Section IV: Results and Data Analysis

Chapter Seven

Summary of Research Findings

Chapter Seven

Summary of Research Findings

7.1 Introduction

Chapters Five and Six analysed in depth the results gathered from pre-clinical and clinical students respectively. In this chapter, the results will be considered together and the differences between pre-clinical and clinical students examined.

7.2 Summary of results from pre-clinical students

The major findings of the results are shown below:

- Pre-clinical LBC students scored significantly higher marks in human genetics examinations than pre-clinical PBL students.
- Pre-clinical LBC students had a significantly better awareness of their genetics knowledge requirement than pre-clinical PBL students.
- Pre-clinical LBC students had significantly better self-reported opinion of problem-solving and critical thinking skills than pre-clinical PBL students.
- Pre-clinical LBC students had a significantly higher capacity of knowledge retention (reflection) than pre-clinical PBL students.
- Pre-clinical LBC students were significantly more motivated than pre-clinical PBL students.
- Pre-clinical LBC students were significantly more confident in conducting self-directed learning than pre-clinical PBL students.
- Pre-clinical LBC students showed a significantly higher level of preparation than pre-clinical PBL students.
- Pre-clinical LBC students had a significantly better learning experience than pre-clinical PBL students.

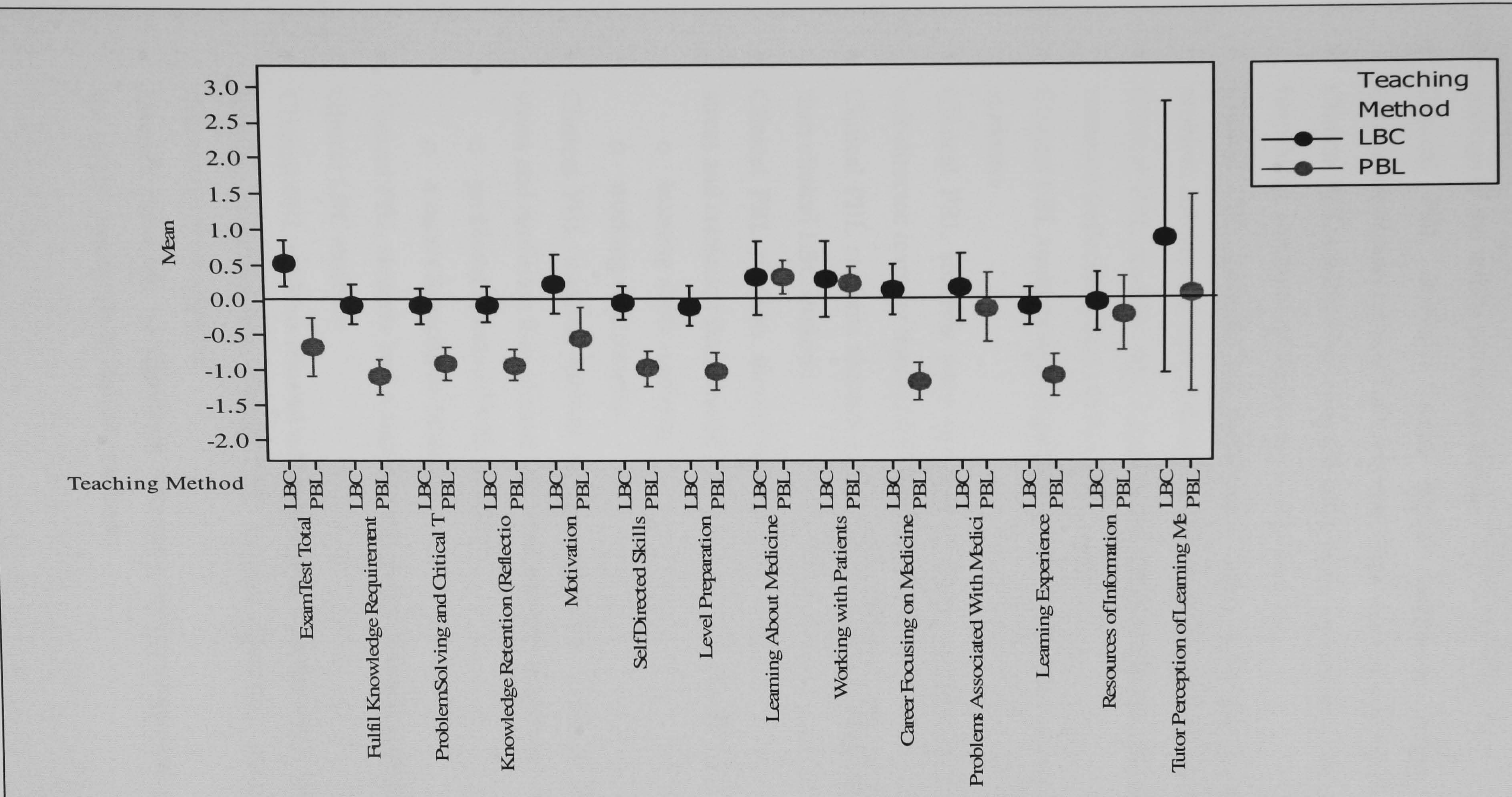
- Pre-clinical LBC students showed significantly lower levels of frustration, stress and confusion than pre-clinical PBL students with regards to a career focusing on medicine.
- Pre-clinical LBC students showed a more positive attitude to the problems associated with medicine than pre-clinical PBL students. Their attitude was significantly different.

The results below are those that did not reveal a significant difference between the pre-clinical LBC and PBL students/tutors:

- Pre-clinical LBC students like working with patients than pre-clinical PBL students; however, the result was not significant.
- There was no different between pre-clinical LBC and PBL students on leaning about medicine.
- Pre-clinical LBC students showed a higher degree of competence when using learning resources than pre-clinical PBL students. However, no significant differences were apparent.
- Overall, there was no significant difference between treatment groups in the tutors' perception of learning methods.

Figure 7.1 brings out the differences between the two treatment groups. Notice that across all subscales, the mean score from LBC students is higher when compared to that of PBL students. This is also true when we look at the tutors. Note, however, that for the following subscales: *learning about medicine*, *working with patients*, *the problems associated with medicine* and *resources of information*, the differences are not very noticeable.

Figure 7.1 Means with 95% confidence intervals for pre-clinical LBC and PBL students and tutors



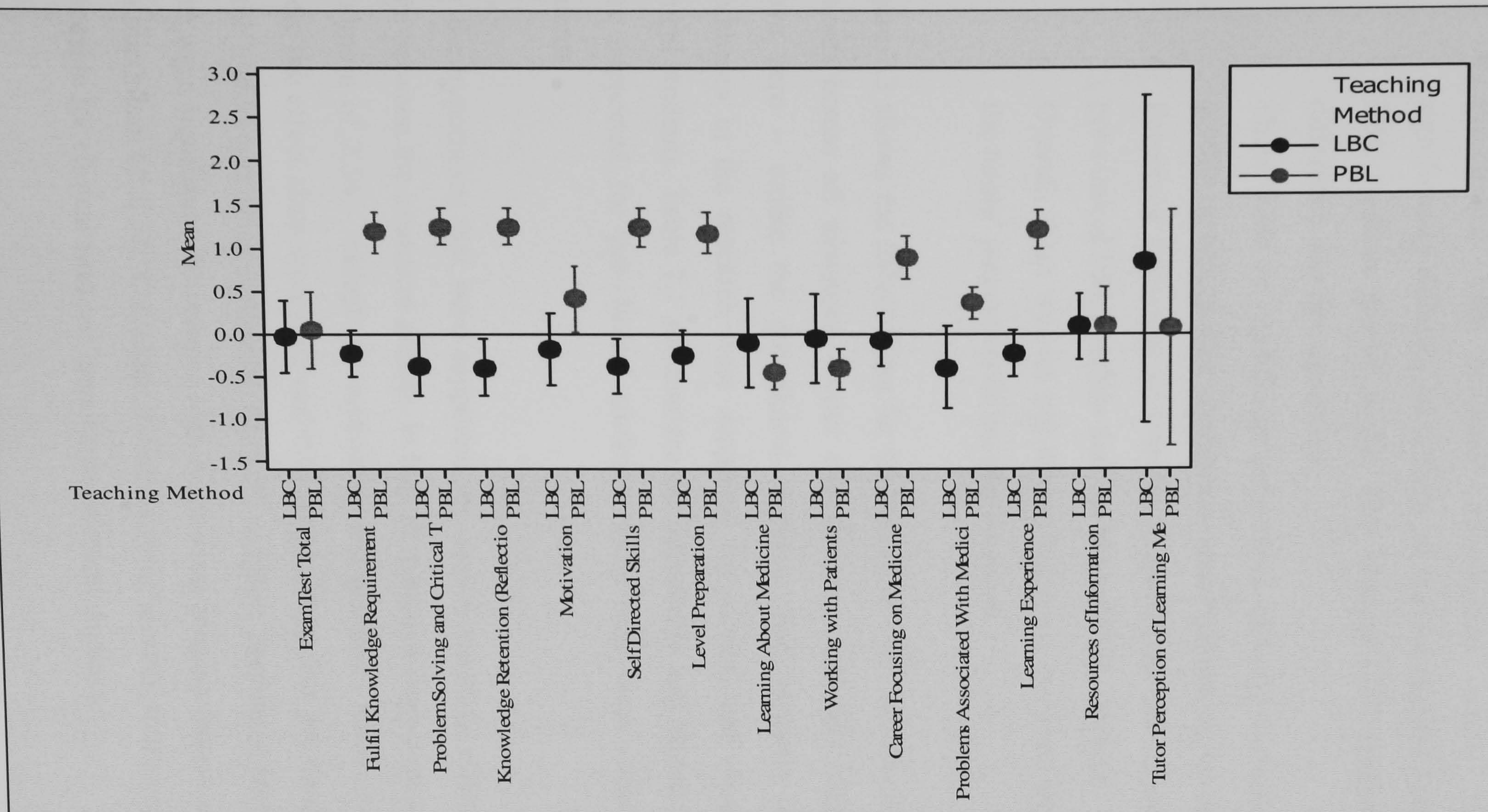
7.3 Summary of results from clinical students

The major findings of the results are shown below:

- Clinical PBL students scored higher marks in human genetics examinations than clinical LBC students. This was not significant.
- Clinical PBL students had a significantly better awareness of their genetics knowledge requirement than clinical LBC students.
- Clinical PBL students had significantly better self-reported opinion of problem-solving and critical thinking skills than clinical LBC students.
- Clinical PBL students had a significantly higher capacity of knowledge retention (reflection) than clinical LBC students.
- Clinical PBL students were significantly more motivated than clinical LBC students.
- Clinical PBL students were significantly more confident in conducting self-directed learning than clinical LBC students.
- Clinical PBL students showed a significantly higher level of preparation than clinical LBC students.
- Clinical PBL students showed significantly higher levels of frustration, stress and confusion than clinical LBC students with respect to:
  - learning about medicine
  - working with patients.
- Clinical PBL students showed significantly lower levels of frustration, stress and confusion than clinical LBC students with respect to:
  - problems associated with medicine
  - a career focusing on medicine.
- Clinical PBL students had a siginificantly better learning experience than clinical LBC students.
- Clinical PBL students showed a higher degree of competence when using learning resources than clinical LBC students. However, no significant differences were apparent.
- Overall, there was no significant difference between treatment groups in the tutors' perception of learning methods.

Figure 7.2 brings out the differences between the two treatment groups. Notice that across most subscales the mean score from PBL students is higher compared to that of LBC students. However, this is not true when we look at the following subscales: *learning about medicine*, *working with patients* and *tutor perception.*

Figure 7.2 Means with 95% confidence intervals for clinical LBC and PBL students and tutors



7.4 Major findings for pre-clinical and clinical students

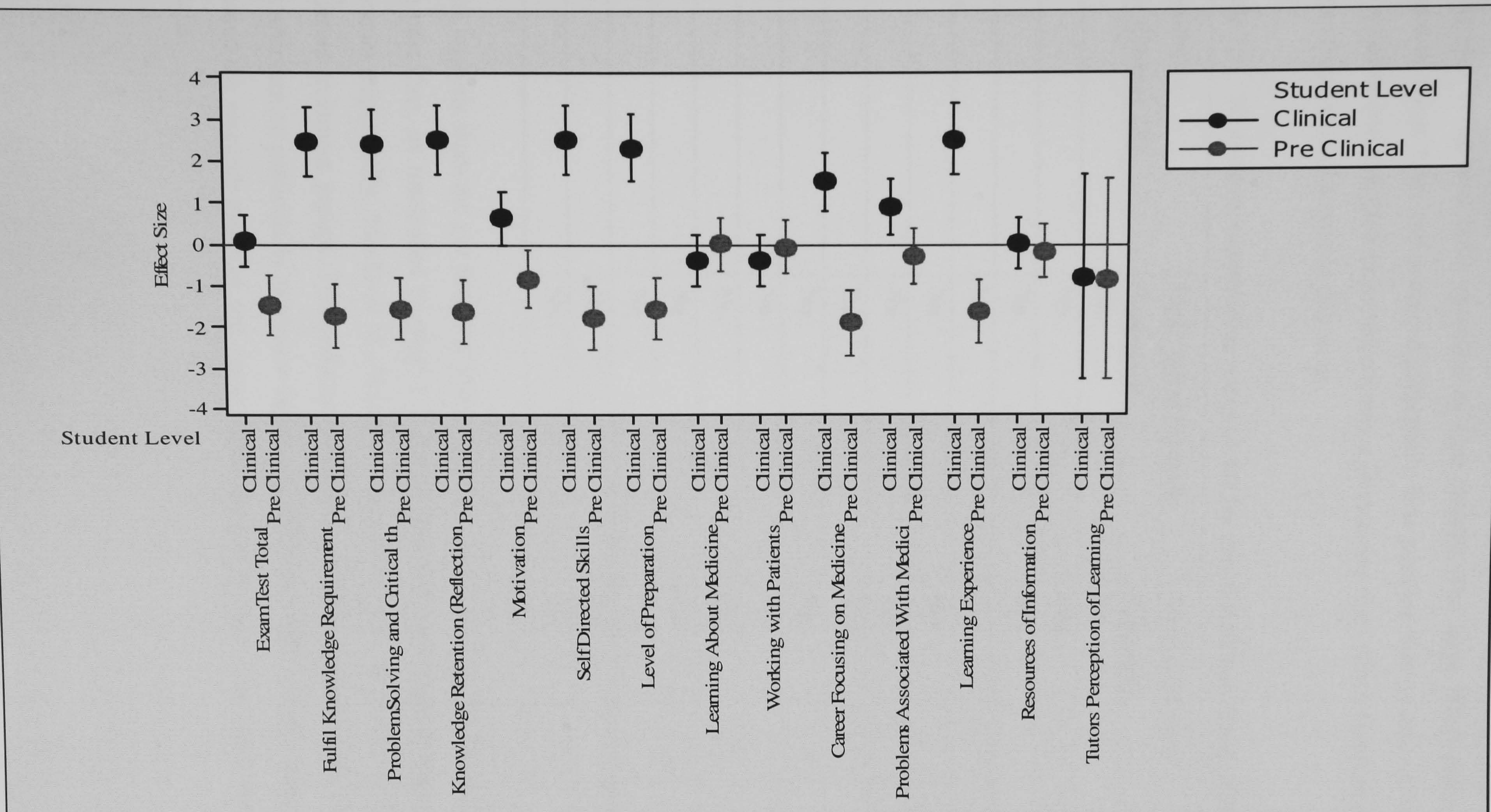
Combining the results of the analyses from both pre-clinical and clinical students, the major findings of this research are:

- On all of the measures, pre-clinical PBL students' scores were lower than clinical PBL students.
- Pre-clinical PBL students' examination scores were lower and significantly different from those of the pre-clinical LBC group. Clinical PBL students scored higher than clinical LBC students; however, the difference was not significant.
- There were no significant differences apparent between PBL and LBC groups regarding their competence in using learning resources.
- Perceived fulfilment of learning expectations was significantly lower for pre-clinical PBL students than for clinical PBL students.
- Overall, there was no significant difference between treatment groups in the tutors' perception of learning methods.

Figure 7.3 shows the Effect Sizes for the impact of PBL for pre-clinical and clinical students across all measures. Notice that for most measures, clinical students are above zero – unlike the pre-clinical students. This indicates that most of the hypotheses in the research were supported for clinical and unsupported for pre-clinical students. Table 7.1 summarizes the hypotheses and shows that none of them were supported for pre-clinical students, while nine were supported for clinical students.

For the hypotheses that were supported for clinical students, effect sizes were very large between the treatment groups. In fact, they ranged from a minimum of 1.52 to a maximum of 2.54 – except for *motivation* and *problems associated with medicine*, where the effect sizes were 0.63 and 0.91 respectively. For pre-clinical students none of the hypotheses were supported, i.e. LBC students performed better than PBL; and there were significant differences with effect sizes ranging from a minimum of -1.92 to a maximum of -0.28. Therefore, the differences between treatment groups are more noticeable for clinical students than for pre-clinical students.

Figure 7.3 Effect sizes with 95% confidence intervals for pre-clinical and clinical students and tutors



As aforementioned, the effect sizes found in this study are generally very large (large effect size being over 0.80, as stated by Coe (2000)). The large effect sizes might appear to result from self-rating of perception. It is possible that groups of students get together and that their experience forms a generalised view which translates to the large effect sizes observed in this study.

Table 7.1 Hypotheses supported or unsupported for pre-clinical and clinical students

Hypotheses	**Pre-Clinical Students**	**Clinical Students**
(See Chapter 2.7)	**Supported**	**Supported**
1	**No**	**No**
2	**No**	**Yes**
3	**No**	**Yes**
4	**No**	**Yes**
5	**No**	**Yes**
6	**No**	**Yes**
7	**No**	**Yes**
8	**No**	**No**
9	**No**	**No**
10	**No**	**Yes**
11	**No**	**Yes**
12	**No**	**Yes**
13	**No**	**No**
14	**No**	**No**

Data analysis from the pre data was generally in disagreement with the findings from the post data, as mentioned in chapter 5 and chapter 6 for pre-clinical and clinical students respectively. The level of effect sizes observed is also dissimilar within the different treatment groups. This enhanced the findings and strengthened the case for the intervention particularly as some students switched from PBL to LBC; some tutors ignored the research protocol and chose which method to teach. See Appendix E for details.

7.5 Summary

In this chapter, the quantitative and qualitative findings raised through the six instruments used in the study have been examined and the results discussed.

In the next chapter, the unanticipated findings of the study will be discussed in relation to Margetson's (1999) notion of a "misconception" which separates understanding from action. The phenomena of "rigorous PBL" and "transitional semi-PBL" will also be described.

Section V: Discussions

Chapter Eight

Discussion I: Understanding Problem-Based Learning in the Light of the Study Results

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Discussion I: Understanding Problem-Based Learning in the Light of the Study Results

8.1 Introduction

The previous chapter summarized the results of this study. On the basis of previous research (reviewed in Chapter Three) it was thought that the introduction of PBL as a method for teaching in Saudi Arabia would have led to more positive findings. Indeed, it was surprising in this study to find that on all of the measures, pre-clinical PBL students' scores were lower than clinical PBL students.

In light of expectations that PBL might be a useful innovation to introduce at Saudi colleges of medicine, the results could be seen as being disappointing. Yet whilst pre-clinical students didn't have high opinions of PBL, it was significantly valued by clinical students.

This chapter attempts to explain the findings of this study regarding pre-clinical PBL Saudi students' experience in the light of existing debates. It will then outline Margetson's arguments regarding "rigorous PBL" and "transitional semi-PBL", to help discern which other educational factors might be operating in PBL programs and to suggest how these courses might be improved. The chapter begins by analysing the weaknesses of the current curriculum in Saudi Arabia.

8.2 Why pre-clinical students are not in favour of PBL

In the Saudi colleges of medicine, the current curriculum is lecture-based or 'traditional' and has attracted considerable criticism. It describes a conventional, didactic and lecture-driven book-based system in which information is derived from rote learning and disseminated to students; it is authoritarian and hierarchical in tone.

Anecdotally, Saudi pre-clinical students are unprepared, almost to the point of hostility, for PBL because it involves a lot of preparation and reading-around the subject, a practice which a conventional, time-critical curriculum cannot accommodate in the early stages. In the clinical stages, however, the students value the PBL interventions more highly. This may in part be due to the working environment for clinical students, which is radically different to that of pre-clinical students and involves working on wards where teaching is 'unconventional', including bedside teaching, small-group examinations and the preparation of short and long case presentations.

Yet this explanation does not seem sufficient to explain the differences in outlook between pre-clinical and clinical students entirely. Unfortunately, many previous studies have tended to focus only on clinical students, omitting to consider differences in perception of PBL between these and pre-clinical students. Studies quoted in Colliver (2000) and Norman (2007) pertaining to the efficacy of PBL interventions deal with clinical students who have already made the transition from the lecture theatre to the ward and have hence become used to a less formal, though equally didactic, environment. It may be that this sparks the 'context activation' that O'Neill (2002) speaks of; that of associating knowledge with first a place (the hospital) and then later with the case (the patient).

The transition from the lecture theatre to the ward may also be the start of the internalization of Eraut's six knowledge categories, in what could be described as "an environmentally-initiated quasi-spiritual change from the familiar formalism and hierarchical environment of the classroom to the unfamiliar but equally formalist hierarchical structure of the ward...more, where the medical student is definitively at the bottom of the power structure" (Fish and Coles, 2005: 94) This experience may spark elements of internal conflict and the need to differentiate oneself from one's fellows: a feeling of, 'I have to prove myself or I will be laughed at'.

Furthermore, the experience of coping on a ward, finding one's way and developing one's place in a new and challenging environment may cause new chains of association to develop, though this particular approach to the issue has not yet been examined.

Smits et al. (2002: 13) conclude:

> "There was no consistent evidence that PBL is superior to other educational strategies in improving doctors' knowledge. The reviews themselves therefore provide contradictory evidence about the effects of different kinds of PBL in different learning contexts."

Problem-based learning acts as an intervention which requires the student practitioner to make an effort and learn for themselves. This may well be unpopular with Saudi pre-clinical students because it also conflicts with the complex mixture of educational theories, philosophies, practices and ideologies. As O'Neill (2002: 236) points out,

> "Students felt there was a conflict between the teaching and learning agendas that they had to learn to negotiate to make the links between their PBL cases and clinical experiences."

Dolmans (2005) points out that previous research shows problems in three areas of PBL. Firstly, he finds that the problems used are too often not real, i.e. paper-based – what O'Neill (2002) calls 'vignettes' – too well-structured, close-ended and simple, whereas real patients are none of these things. Furthermore, Dolmans claims that the tutors are too dominant, didactically *informing* students rather than *guiding* them so as to help them find the information for themselves. Indeed, in the current study, 14 of the pre-clinical PBL students found the facilitators authoritarian; this was in fact contrary to our expectations and to Barrows's claims (1988). Dolmans further states that PBL tutorial groups are "dysfunctional": apathetic, cynical about the whole idea of PBL, unprepared for sessions, lacking motivation, without cohesion, and so forth. He concludes (2005: 735):

> "These problems usually stem from a poor interpretation of PBL and hence that the learning process does not stimulate students towards constructive, self-directed, collaborative and contextual learning."

As a result of poor interpretation, so-called PBL curricula have often failed to fully satisfy PBL criteria. Margetson (1999) refers to this sort of curriculum as 'transitional, semi-problem-based' rather than rigorously problem-based.

Certainly, without some form of change, Margetson's idea of the "misconceived" separation of understanding from action is more likely to be repeated by students guided by tutors who don't really understand what PBL is or how to apply it. Attempts to avoid the issue by developing curricula resulting in 'semi-problem based' rather than 'rigorously problem-based' learning may compound the problem.

It is also the case that, in large-scale meta-analyses of experiments, there have been results which do not appear to have been predictable by the methodology. Much of the current debate hinges not on the idea of PBL but on the form of the experimental design methodology and the consequent reliability of interpretation.

Lastly, I consider that the underpinnings of PBL as an educational innovation are unclear. This represents a further uneasy compromise between the ideas underlying PBL interventions which aim to make the learning environment more interesting for the student and hence enhance knowledge retention, and the mechanistic requirements of skills laid down by the various certifying boards or colleges of medicine worldwide. The 2002 conference 'Saudi Medical Education: Future Perspectives' (as reviewed in Chapter One) identified the following as crucial factors in the need for curriculum revision:

- An overcrowded curriculum
- Over-representation of some subjects
- Presence of non-relative subjects
- Disassociation between basic and clinical sciences
- Repetition of lectures and examinations
- A need for new subjects of clinical relevance.

Most of these criticisms have also been made by the General Medical Council (1993) with regard to traditional curricula in the UK.

8.3 PBL as educational innovation

PBL is one of several innovative approaches to medical education, and Barrows (1980) was the first to indicate in depth the rationale for it. Barrows has described "a fundamental postulate" of this approach, which is that professional education should be "effective for creating in a student's mind a body of knowledge *usable* in the future" (1980: 20).

However, there have been dissenting voices in previous literature. Rolfe et al. (1997: 265) put forward the following ideas, from first-hand experience of PBL as a student:

> "Understanding alone is insufficient ... knowledge must be applied and translated into action... the medical course at Newcastle had given me an enthusiasm for my future learning and the desire to maintain the change in medical education."

Margetson (1999) asks two major questions in order to understand the postulate of Rolfe et al. (1997) and how PBL relates to it: "Does problem-based learning satisfy this postulate, and does problem-based medical education represent an improvement on traditional medical education?" (1999: 359), and challenges Rolfe, claiming that "if we misunderstand how to achieve a valuable aim and therefore go about it in the wrong way, we may defeat the achievement of the very aim that we seek" (1999:360).

Indeed, Margetson suggests that there is a powerful misconception of professional education (and of PBL in relation to it) which threatens the improvement of medical education (O'Neill et al 2002, Dornan et al, 2005). This "misconception" needs to be understood in some detail.

8.4 Margetson's "misconception"

8.4.1 Separating understanding from action

Margetson (1999:360) defines a "misconception" of "the separation of *understanding* from *action*", supporting this definition with the following example:

> "An individual may be able to understand a text without being able to act upon that understanding, or, more generally, it can be said that this same individual is full of 'book-learning' but unable to practise" (1999:360).

In relation to the present study, it could be that pre-clinical students might come to *understand* the genetics of the problem case they are studying, but it would negate the educational process if they were unable to act on that understanding, to use that understanding in practice. Seen in this way, Margetson's "misconception" applies not just to PBL but to *any* educational situation which separates understanding from the action that it is supposed to inform. This is a crucial criticism for medical educators to consider.

In fact, the results of this study suggest that pre-clinical students were not only more negative than clinical students in their perceptions of PBL, believing their knowledge acquisition and ability to study independently to be compromised by it, but, more significantly, their examination grades were lower than the lecture-based students who were studying exactly the same material. There is, therefore, some question both about the understanding of the pre-clinical PBL students in this study, and the extent of the application of the curriculum intervention.

In the setting of the present study (and according to Rolfe), the PBL intervention for pre-clinical students occurs as a three-stage process. First, the student learns to understand genetics from clinical cases that are presented in the form of 'problems' (i.e. on paper). Second, the student discusses these problems and tries to understand them. This stage was termed by Rolfe et al. (1997: 265) the "body of knowledge in the student mind", and is where the student is thought to 'activate prior knowledge' (Fish and Coles, 2005). In this stage, the student scans for new information, creates new hypotheses, sorts the hypotheses to activate existing knowledge, and develops learning objectives to direct the gathering of new information in order to understand the problem. Third, the student applies the knowledge by "translating" it from theory into action through clinical application.

Margetson illustrates, and begins to challenge, the three-stage process using the following example:

> "The student may, through reading a medical text, gain understanding of the nature of a simple injury such as a minor cut. Gaining this understanding is regarded as a quite different process from the process of attending to an actual injury (which might involve covering the cut with a sticking-plaster), and relations between the two processes are attributed to a third process of internal mental 'translation' and 'application' of understanding in a particular action" (1999: 361).

In the present study, we could translate this into questions such as: How does the facilitator know whether or not the students have understood the patient's problem? Does understanding the genetics of the problem mean that the clinical problem is understood? Will these students be able to apply their knowledge in a clinical setting? (Littlewood et al., 2005). In reality, these are difficult questions to find responses to and certainly the data from this study can only infer some answers rather indirectly. Nevertheless, the data does support Margetson in asking those questions.

Margetson continues, "what we see applied is not the student's understanding" (1999: 361). Rather:

> "We judge the extent to which the student understands the given situation by what the student can say and do. An appeal to separate internal processes of understanding, followed by further, separate processes of translation and application, contributes nothing to understanding action and practice, although, of course, associated internal physical processes certainly occur. Many internal physical processes are going on when we try to understand something, and it is important in medicine to understand these, but they do not give us the meaning of understanding. They underlie the actions and practices that we may wish to understand as actions and practices. We may also wish to understand underlying physical processes, and we may wish to understand the relation between these and actions and practices, but this is no reason to confuse one with the other." (1999: 361).

Margetson describes practical action as:

> "Intentional, not merely mechanical - a distinction illustrated by the point that an individual is not generally regarded as responsible for their actions if they were under the influence of hypnosis, or medication. This distinction may be signalled by referring to what individuals do intentionally, as action, while what they do under over-riding influences may be referred to more generally simply as behaviour" (1999: 361).

8.4.2 Separating pre-clinical from clinical

> "In traditional curricula there was a general separation between the acquisition of knowledge of "basic" science in the pre-clinical early years, and clinical "application" in the later years" (Margetson, 1999:362).

This separation is also true, as Margetson (1999: 362) notes, of most PBL curricula:

> "A parallel separation occurred between the acquisition of "basic" science knowledge needed to solve a problem in the early years, and inquiry into solving the problem in the later years."

Indeed, this was the curriculum arrangement in the present study, whether for the problem-based or the lecture-based students. This separation of pre-clinical and clinical implies, in Margetson's terms "knowledge first, application second" (1999: 362). But this, in Margetson's view, is "misconceived" in its separation between understanding and action. In traditional curricula, "understanding is identified with a pre-clinical acquisition of "basic" knowledge in a context-free way, and action is identified with the "application" of the acquired knowledge during clinical practice" whilst in problem-based learning, "understanding is identified with the acquisition of "basic" knowledge in the context of clinical problems, and action is identified with learning how to solve clinical problems later on during clinical practice" (Margetson, 1999: 362).

8.4.3 Transitional semi-problem-based and rigorous problem-based curricula

Margetson suggests that much of what is called problem-based learning is in fact what he would prefer to call "transitional semi-problem-based" rather than "rigorous problem-based". One of the features of a "transitional semi-PBL" curriculum he describes as "the misconception that a problem is merely a curriculum device" (1999: 363).

> "In transitional semi-problem-based curricula problems are simply "convenient pegs" on which to hang the coat of 'basic' science knowledge which students need to acquire; much later, students will 'apply' the 'basic' knowledge in actual clinical situations during the clinical practice phase of their studies. Thus theory and application are separated. Understanding is associated with theory and application with practice in a reductionist view of the relation – reductionist in the sense that clinical practice is largely reduced to a matter of 'applying' scientific knowledge to clinical cases." (1999: 363).

However, Margetson (1999:363) describes "rigorous" PBL as a "growing web" which occurs with the development of an integrated coherent whole of understanding, knowledge and skills in practice. He indicates that:

> "In medical education, the acquisition of knowledge occurs in intricate conjunction with learning how to solve clinical problems.... Medical problems are constitutive of medical practices, not merely instrumental (just as other kinds of problem are constitutive of other kinds of practice). On the "growing web" conception the typical student's understanding, knowledge and skill are interrelated, forming a whole which develops in response to problems. At the beginning, this is of course a rudimentary, small whole, but it is a whole nonetheless. Throughout the course of study, the inter-related whole of understanding, knowledge and skill grows to approach that of a competent professional practitioner – and the quality of a curriculum is judged in terms of the extent to which it either helps or abandons students in their efforts to attain such competence."

Using this analysis, it seems reasonable to suggest that the PBL offered to the pre-clinical students, although well intentioned as an appropriate innovation, was in practice no more than 'transitional semi-PBL' (Dornan et al, 2005, Dornan, Hadfield et al, 2005), and hence had problems which were not merely associated with a new innovation, but also may not have been well understood by its tutors and facilitators. Dolmans (2005: 735-737) points out that

> "what is needed in PBL is transition from tutor regulation or external guidance…to student regulation or internal guidance...the best tutor knows how and when to intervene, and has the student's learning as his top priority".

8.4.4 Success and failure in conventional and problem-based curricula

Margetson (1999:364) notes that the weaknesses of conventional curricula (as seen in the Saudi colleges of medicine, and those referred to by the GMC in 1993):

> "Are significantly reduced in the transitional semi-problem-based kind of course; but they remain very influential none the less, for they continue to reflect thinking and practice in terms of the generative misconception which was also central to the traditional curriculum."

Margetson sees three failures resulting from separating understanding and action, and considers these to be as true for transitional semi-problem based learning as in conventional curricula:

> "Firstly, it is atomistic in regarding the pre-clinical phase and the clinical phase as two distinct parts, brought into relation through the mechanical notion of 'application'. In some PBL curricula, the two phases are not formally named pre-clinical and clinical (as they often are in the traditional curriculum) but the reality of the practice shows that the division is present – and informal discussion in these terms is not uncommon. Secondly, it is atomistic in conceiving the two phases as quite separate in nature, the one being theoretical and the other practical, with associated tensions of the kind rife between different 'academic tribes and territories' (Becher, 1989). And thirdly, it is atomistic in seeing the pre-clinical phase as an absolutely secure foundation on which clinical practice rests, following discredited foundationalist views of knowledge" (1999: 363).

But this raises the question; if the Margetson "misconception" can be seen in PBL curricula that retain the separation of understanding and action, why is it that many studies of PBL (reviewed in Chapter Three) have indicated some success? And related to this, why did the clinical PBL students in the present study show some (limited) educational gains over the lecture-based students and indicate more of a preference for PBL than pre-clinical students? It may be that the clinical PBL was more realistic than the pre-clinical PBL, in that clinical PBL students already have clinical training within their curriculum, while pre-clinical students are not. (In passing, we might note that PBL tutors were enthusiastic about it too, and this requires some explanation).

It is likely that where PBL "works" (that is, where it shows some gains over conventional curricula) it does so because other educational factors are operating. All the research thus far is clear on this point: the disagreement is exactly what other factors are operating. The experimental design is not intended to capture this, but the additional data does throw some light on the issue.

Where PBL has been shown to be "successful" elsewhere with pre-clinical groups, this could be because students applied what Coles (2000) called "deep processing" – they attempted to understand what they were learning. While this could be considered educationally sound, and an advance on conventional curricula which have been shown to induce "surface processing", (Fish and Coles, 2005) pre-clinical PBL might still fail to provide students with 'understanding' that could be used in action. Thus, while there might be an immediate educational benefit, there could be little longer term benefit when these students subsequently entered the clinical phase (Littlewood et al, 2005, Colliver 2000). The studies of such curricula are quiet about how well PBL pre-clinical knowledge is used in the clinical years and in medical practice later; a long-term follow-up on students from such PBL courses would be unusual.

Colliver (2000) and Newman (2006) appear to suggest that there is no long-term advantage in knowledge retention in PBL as compared to traditional training courses. In the case of the clinical PBL group in the present study, where there were some positive findings, it could be that the students made connections between the paper-and-pencil problems of the PBL teaching and their own first hand experience of similar clinical situations which they were now encountering themselves. The same might be occurring for the tutors. It could be that they were able to see the relevance of what the students were learning (even when the students were unable to see it) because they too could relate it to their own practical experience, all of which paradoxically supports the Margetson analysis (Prince et al., 2005).

It seems reasonable to suggest that in this study, the PBL arrangement for the pre-clinical students failed educationally because, like any transitional semi-PBL curriculum, it segregated understanding from action. Whilst this is also true for LBC, pre-clinical PBL students suffered more greatly from this segregation because they were not prepared for tackling cases, not yet having been exposed to clinical training. For clinical students, however, where the PBL arrangement succeeded, this was because, like rigorous PBL, it created the educational conditions needed to develop in the students' and tutors' minds a growing web of understanding in the action of clinical practice.

8.5 Summary

In this chapter, an attempt has been made to explain the unexpected results of this study have been explained in terms of Margetson's "misconception", in which many educational programs, including what he calls "transitional semi-problem-based curricula", separate understanding from action. Rather than providing "a convenient peg" on which to hang the so-called basic sciences, clinical problems should (in Margetson's view) be a significant part of a "growing web" of knowledge, which would render what is learned usable in later clinical practice. The circumstances behind the poor performance of Saudi pre-clinical students have been outlined, and an explanation attempted, in light of the available literature and of Margetson's arguments.

It is a logical, though unproven, assertion that the pre-clinical students, products of an authoritarian and didactic school environment from primary school to university, react with hostility, expressing disinterest and withdrawal regarding an innovation which puts success or failure on their shoulders by emphasizing personal work, and that their tutors either insufficiently understood the PBL requirements or were either over- or under-involved. It is a logical, though unproven, assertion from the evidence and literature available that clinical students, whose exposure to the ward environment requires them to work more individually (though no less collaboratively) would be more attracted to this form of teaching and that their tutors/mentors, burdened with their own clinical responsibilities, would be unable to intervene at more than arms length or with any regular timetabling.

Both these assertions are logical and, in light of the debate in educational circles on this subject, also credible as points of initiation for research, but like everything related to PBL, they require more directed research to prove.

In the next chapter, the work of other educational writers is reviewed in relation to their support of Margetson's argument regarding the relationship between understanding and action.

Section V: Discussions

Chapter Nine

Discussion II: Supporting Arguments of Other Educational Writers

Chapter Nine
Discussion II: Supporting Arguments from Other Educational Writers

9.1 Introduction

In Chapter Eight, Margetson's work (1999) provided some explanation for the results of this study. He described a fundamental "misconception" in education, which separates understanding (theory) from action (practice) which even occurs in some forms of PBL. The educational experience of the pre-clinical students in the present study fits with what he called "transitional semi-PBL" which he suggested is educationally no different from the traditional or lecture-based method (LBL) in the way it separates understanding from action. On the other hand, the clinical PBL students experienced a more rigorous form of learning, probably because by then they had gained more first hand clinical experience (action) to which they could relate their understanding of genetics.

In this chapter, the notion of there being a "misconception" is recast as two questions:

- What is the relationship between theory and practice?
- How ought this relationship to become a basis for professional education?

In passing, it should be noted that the first question is essentially a theoretical one (with some practical implications) while the second one is essentially practical (with, of course, theoretical implications). Relevant arguments by other educational writers are examined in this chapter, in order to determine what support exists for Margetson's views.

9.2 What is the relationship between theory and practice?

Golby and Parrott (1999: 59) note that "practice is an abstract noun whose verb form is practise. Thus practitioners practise and what they practise is a practice." It could be said in much the same way that "theory" is an abstract noun whose verb is "to theorise". Thus, to paraphrase Golby and Parrott, theorists theorise, and what they theorise about is theory. So, when talking about the relationship between theory and practice, there are two ideas of each: "practise" as a verb and "practice" as a noun, and "theorise" as a verb and "theory" as a noun.

According to Golby and Parrott's (1999) definition, "practice exists whenever a more or less settled body of activities is carried on to some distinctive end" (1999: 7). This is true not only of doctors (and teachers), but also of footballers (in that football is a more or less settled body of activities carried on to some distinctive end). But for Golby and Parrott, professional practice should be thought of as more than skilled performance. This view is supported by MacIntyre (1981), who defines practice (in medicine?) as:

> "Never just a set of technical skills... What is distinctive of a practice is in part the way in which conceptions of the relevant goods and ends which the technical skills serve – and every practice does require the exercise of technical skills – are transformed and enriched by those extensions of human powers and by that regard for its own internal goods which are partially definitive of each particular practice" (1981:81).

Freidson (1971), in discussing the nature of a professional, suggests:

> "The kind of work they do is believed to be especially important for the well-being of individuals or of society at large, having a value so special that money cannot serve as its sole measure..." (1994:200).

This concept moves towards what Carr (1995) defines as a "moral dimension" of professional practice within the caring professions, introducing the notion of human welfare and of practice as a moral endeavour, i.e. for the good of the other person (Tallis, 2005; De Cossart and Fish, 2004).

In examining Aristotle's theories about practice, Carr (1995) suggests that it has two forms; one in which something is made and one in which something is done. He talks about how at the end of *techne* (technical knowledge), an object is produced, but the result of *praxis* (doing something) comes the realisation of some worthwhile good: a moral endeavour. He considers there to be a distinction not between theory and practice, but between two kinds of practice, which will have different forms of theory associated with them. This both supports and develops further Margetson's (1999) view of the separation of understanding from action that often occurs in education and can leave an individual knowledgeable but unable to practise. Carr considers that theory is formed in and through practice, not separate from it and certainly not prior to it.

Golby and Parrott (1999: 9) think of practice as a tradition of conduct: "A tradition of conduct itself is made up of contemporary practitioners who are in turn related to predecessors who have bequeathed their practice"; Carr adds that medicine and education are part of their own distinctive traditions of practice but, because they deal with worthwhile things and are moral endeavours, practitioners cannot simply replicate the activity of their predecessors; instead, practice must remain open to some kind of critique:

> "The authoritative nature of a tradition does not make it immune to criticism. The practical knowledge made available through tradition is not mechanically or passively reproduced: it is constantly being reinterpreted and revised through dialogue and discussion about how to pursue the practical goods which constitute the tradition." (1995:69)

For Carr (1995: 69), "it is precisely because it embodies this process of critical reconstruction that a tradition evolves and changes rather than remains static or fixed."

Thus a professional practice must encompass the notion of 'critical reconstruction'. As practitioners join a tradition of practice, they should not blindly accept what others do or unreflectively follow a set of rules (as they would when making objects); rather, they should critically reconstruct the traditions of practice for themselves. In this way, not only will their own practice be appropriate, but that of the profession as a whole will be rejuvenated.

Taking this into consideration, the way in which the notion of theory fits with that of practice becomes clearer. The critical reconstruction Carr identifies as "practical reasoning" or "deliberation and judgement" is involved in becoming and being a practice, but between two kinds of practice, which will have different forms of theory associated with them. This both supports and develops further Margetson's (1999) view of the separation of understanding from action that often occurs in education and can leave an individual knowledgeable but unable to practise. Carr considers that theory is formed in and through practice, not separate from it and certainly not prior to it.

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This may be interpreted as a criticism of the current health care practice, which recommends that practitioners follow protocols instead of empowering professionals to make moral judgments. Carr recognizes the case for developing professional judgment:

> "Since the ends of a practice [in the caring profession] always remain indeterminate and cannot be fixed in advance, it always requires a form of reasoning in which choice, deliberation and practical judgement play a crucial role. This form of reasoning is, for Aristotle, distinguishable from technical forms of reasoning by virtue of its overall purpose and the structure of reasoning it employs." (1995:70).

Doctors (and teachers) often face difficult situations which require them to use their judgment to resolve moral dilemmas .For a doctor, an extreme example of this could be Siamese twins, joined by one liver: the surgeon, in conversation with relatives, must make the decision as to which one lives and which one dies. Aristotle stated that it is *phronesis*, 'practical wisdom' – "the knowledge of what is required in a particular moral situation" (Carr, 1995:71) – which informs these kinds of difficult decisions, and that someone who has *phronesis* is the "*phronimos*" (the man of practical wisdom); the man

> "who sees the particularities of his practical situation in the light of their ethical significance and acts consistently on this basis. Without practical wisdom, deliberation degenerates into an intellectual exercise, and 'good practice' becomes indistinguishable from instrumental cleverness. The man who lacks *phronesis* may be technically accountable, but he can never be morally answerable." (Carr, 1995:71)

Consequently, for Carr, the kind of education needed to produce doctors (and teachers) is based on the creation of *phronimos*: people with practical wisdom who can engage in *praxis* (ethically enlightened action). Carr, in agreement with Margetson, argues that there should be no division between theory and practice. For Carr, the question was not how to bridge theory and practice, but rather how to determine what kind of theory is related to what kind of action (if the action is *praxis* then the theory needed is 'practical wisdom'; if the action is *poeisis* then technical knowledge is needed). Carr summarizes the relationship between theory and practice, by recognizing that they are: "mutually constitutive and dialectically related domains" (1995:50).

Theory is not "related" to practice except insofar as practice is at the same time related to theory. Rather, theory and practice co-exist – one cannot exist without the other. The process by which this occurs is 'practical reasoning' or, as Eraut (1994) puts it, the process of "theorising": by recreating knowledge in practice. Carr supports Margetson's notion of a misconception separating understanding from action and then, with reference to Aristotle's concept of moral endeavour as professional practice, develops the theory to encompass a need for practical reasoning.

These discussions help to explain the findings of the present study. The pre-clinical students (even those who used PBL) failed to capture the nature of practice as a moral endeavour in the problems they studied. It seems that for them, theory was merely an academic pursuit, divorced from practice; whereas practice was treated as a technical process. The clinical PBL students, on the other hand, may have approached practice as a moral endeavour if they had firstly associated the problems with their own experience and secondly used "practical reasoning" alongside their existing experience to inform their responses. It is perhaps significant that the clinical students' motivation was 'intrinsic' (coming from within, and therefore more likely to be related to ethics) whilst the pre-clinical students' motivation was 'extrinsic' (more instrumentally orientated).

9.3 How ought the relationship between theory and practice become a basis for professional education?

9.3.1 Why is there a theory-practice split in professional education?

The previous chapter noted how conventional undergraduate medical curricula (and many problem-based ones) separate (in Margetson's terms) understanding and action (theory and practice) as seen in the pre-clinical/clinical division of the course. Before proceeding further we should speculate why theory and practice are separated in this way.

Carr suggests that this split may be traced back to Plato and his notion of "perfect forms", a philosophical division that was adopted in Kant and Descartes' principles of "Dualism" (separating mind and body). Hence, one explanation for a pre-clinical/clinical split in the curriculum may be that the scientists involved consider that they are dealing with "pure" knowledge that is necessarily decontextual, or "generalisable". Another reason for the division may be that of practitioners wanting to keep practice separate from theory because of the very mysteriousness, the ineffability, of professional action. Equally, it may be that an understanding of complex theory requires a sustained period of study, and that people have found that libraries, seminar room and the lecture theatre are the best places to do this, in so doing separating theory and practice. As aforementioned, professions are distinct from each other because of their 'traditions of practice'.

Whatever the reasons for this separation of theory from practice, it has a significant and wide-reaching influence in medical education. Nevertheless, a number of educationalists have in recent years suggested ways of more closely relating theory with practice. Their contribution, already reviewed in Chapter Three, will be briefly summarized here so as to establish links with the previous discussion in Chapter Eight.

9.3.2 Experiential learning model

Barnett et al. (1987:54) suggest a model of professional preparation which removed the division between theory and practice:

1. Professional education consists of developing practical skills, being able to analyse and reflect on them, and being able to continue learning on an ongoing basis, and these are all inter-related
2. Theory is a body of knowledge directly related to and illuminating practice
3. Practical experience is of the highest importance, but must be accompanied by reflection and analysis

4. Academics need to address practical problems and be conversant with professional realities
5. Practitioners need to be full partners in the enterprise of initial professional education

Kolb (1984), Marisick & Watkins (1990) and Boud et al. (1983) challenge lecture-based case models of instruction, providing support for emphasis on experiential learning and hands-on experience within the curriculum. In particular, Kolb (1984) acknowledges that the ideal learning cycle is one where the student moves from concrete experience to observations and reflections, then through the formulation of abstract concepts and generalizations, and on to a stage of testing the implications of these concepts in new situations within the context of new experiences (see also Dornan, 2006 and Dornan et al., 2007).

9.3.3 Reflective learning model

Kolb (1984), Kilty (1982) and Freire (1972) note that experience alone is not sufficient to ensure that learning takes place. They place importance on the integration of new experience with old, through the process of reflection. In order to learn, it is necessary to be able to reflect on actions and to undertake some sort of critical appraisal of the findings. Here, the word 'critical' is used to denote the process by which students ponder, sift, analyse and evaluate: it should not be taken as meaning only 'to judge negatively'.

Usher (1986a) emphasizes the role experience has as a major resource for learning, but views it not as a replacement for learning:

> "Courses based only on work experience suffer from the danger of becoming excessively technical in orientation and thus undesirably narrow in both curricular terms and in the doctor's personal development" (1986a: 125)

Usher's joint work with Bryant (1987) argues for the need to bring together practice and theory, stating that practice can generate its own theory but theory may not necessarily be directed to practice, such that "we can see theory and practice as interactive and mutually enriching" (1986a: 126).

Usher (1986a) indicates how important reflection and activity are to learning, which in turn is informed by experience. Marsick & Watkins (1990) emphasize this relationship: "learning takes place through an ongoing dialectical process of action and reflection".

Reflection can be a solitary, introspective act, or it can be a group process whereby sense is made of an experience through group discussion. If reflection as a group activity is to be successful, the teacher is required to act as a group facilitator. The skills associated with group facilitation differ from those associated with the usual process of teaching: the group facilitator takes a non-directive and non-authoritarian stance in relation to the students. In a reflective group, the teacher neither ascribes meanings to experience nor offers explanations, but allows and encourages the students to do these things for themselves.

Examining how professional knowledge is created requires a wider view than merely examining the work of theorists. Eraut (1994:21) states that knowledge is also created in a practice setting, albeit of a different kind than that created by theorists:

> "Moreover, in some professions nearly all new practice is both invented and developed in the field, with the role of academics being confined to that of dissemination, evaluation and *post hoc* construction of theoretical rationales. In others, knowledge is developed by practitioners 'solving' individual cases and problems, contributing to their personal store of experience and possibly that of their colleagues but not being codified, published or widely disseminated...professional learning suggests that knowledge use and knowledge creation cannot be easily separated. The interpretative use of an idea in a new context is itself a minor act of knowledge creation, perhaps more original than one of the more derivative types of academic paper. Moreover, these two creation processes may not even be distinguishable because new practice rarely gets invented from scratch: ideas from the published literature usually have an influence somewhere even if it is not realised at the time."

Eraut (1994:21) describes how: "theory is derived from practice by a process of reflection on, and theorising about, practical experience."

9.3.4 Situated learning model

Collins (1994:54) declares that learning must be both situated and unsituated. He emphasizes the difficulties of situated knowledge in apprenticeship training as:

> "Things are usually taught in a particular context with no generality. So there is a *flexibility* problem; learners only learn to do things in one way and do not adapt easily to other methods. There is a *learning* problem; learners do not develop a global framework to organise their knowledge, and there is a *transfer* problem; learners do not learn how to apply their knowledge to new situations that look different from the context in which they learned."

The difficulties of unsituated knowledge, for Collins (1994:55), are as follows:

> "The problem of unsituated knowledge is evident in most of the school curriculum. Things are taught out of the context of their potential use to students. So there is a *motivation* problem; learners often do not see the point of what they are learning. There is an *interpretation* problem; learners have no idea how to apply much of what they learn to the problems that arise in their lives. And there is a *retention* problem; it is hard to remember abstractions, like how to add fractions, if one never uses the knowledge."

9.3.5 Contextual learning model

Coles (1985b), in proposing what he calls a contextual learning model, furthers the above ideas in stating that the context becomes the starting point for the theory and that in turn, context leads to a better understanding of the information. Furthermore, information and skills can be integrated around practical issues, ensuring that real understanding is achieved and indicating that skills are achieved through gaining an understanding of their use in context. Coles describes a "contextual model" that is a means to achieving elaborated learning through three conditions:

> "Students must have an appropriate context for learning; they must be provided with or acquire information potentially relatable to that context; and they should have opportunities to so handle the information that they make the connections" (1985b: 305).

Coles argues that the type of learning students ought to be undertaking, especially when studying to enter a profession, is one which involves 'deep processing' (Fish and Coles 2005): students should understand the meaning of what they are learning. Studies have shown that 'surface processing' results in poor course performance, although they have not clearly shown that 'deep processing' results in good course performance (Fish and Coles, 2005).

Broadbent (1975) argues that the more links students have between the elements of knowledge learned, the easier it will be to recall and use that knowledge. This view is supported by Mayer (1979) and by various other authors writing in direct reference to medical education (Amin and Khoo, 2003: Dolmans et al., 2005; and Tan, O., 2007). All the aforementioned theorists endorse the fact that the student will have a better ability to understand and solve problems if they have an "elaborated conceptual knowledge" and "access to an appropriately structured memory comprising a deep, rich knowledge" (Fish and Coles, 2005).

Coles states that traditional methods of education do not often result in 'elaborated learning' in students' pre-clinical training but that this has in the past been shown to exist after students had gained experience through clinical training. Patel and Dauphinee (1984) also find evidence of elaborated learning in students who had been retaught basic science whilst learning within a clinical environment. For Coles, this indicated three things: that students need hands-on experience to give them a context for their learning; that they need relevant theoretical information both in the form of what they are taught and their own revision notes; and that they need to be able to apply this information to their clinical studies. He describes this as "contextual learning" (Fish and Coles, 2005).

Students need to be able to relate new information to an existing framework of "knowledge, conceptualizations and experiences" so that they can achieve the "deep processing" required for a comprehensive knowledge base. Students recognize when the relevant links have been made between elements of knowledge: they feel things falling into place and becoming clear. However, this is not something that happens without effort and unless the students are taught and encouraged to develop a structure for their knowledge and to form links between new and existing information, they will not achieve this clarity (Dornan et al, 2006). Coles emphasizes, however, that whilst the student can be encouraged to learn in this way, they can only achieve it for themselves:

> "Learning must be an active process on the part of the learner (Rogers, 1960). While elaboration is something only an individual student can do, it can of course occur when students work in groups (Walton, 1973). The contribution of group work to each student's elaboration processes is that it allows the opportunity to articulate one's thoughts in a safe environment, and to receive constructive feedback from peers" Coles (1985b: 305).

9.4 Summary

In this chapter, a general support for Margetson's misconception has been illustrated. The idea has been furthered by arguing that the issue is not one of separation of understanding from action, but of what *kind of action* is involved in professional practice and what *kind of knowledge* is required to drive it. This is a matter of practical reasoning rather than technical reasoning, and is the distinction that Schön raises when he speaks of practice as "professional artistry" rather than the application of technical knowledge.

Many writers reach the conclusion that, to minimize the gap between theory and practice in medical schools, students need opportunities to gain first-hand practical experience and to develop the capacity to reflect on that experience, or to "theorise" about it, in order to understand the experience and to develop appropriate theory in relation to their practice, in order to make sense of it.

The various educationalists discussed in section 9.3 suggest ways in which curricula may be arranged in professional education, and each in turn indicates a particular relationship between theory and practice. What they lack, however, are convincing indications that their models satisfy Margetson's "misconception" or Carr's notion of the "mutually constitutive" relationship between theory and practice; through what he calls "practical reasoning" or "deliberation". Perhaps Coles' contextual learning model comes closest to this when he speaks of the need for a curriculum model which links theory to practice, but even this falls short of the Margetson/Carr ideal which denies the need to "link" theory and practice but requires practice and theory to grow together.

Also, it is significant to note here that Barrows (who was one of the earliest writers to describe PBL for medical curricula) has shifted his position (Barrows, 2000). Now, rather than speaking about *problem*-based learning, he recommends what he calls *practice*-based learning, thus focusing attention on the primacy of practice.

Carr, too, would agree with this move, which is not only a shift of emphasis, but, more than that, is a philosophical advance. He notes that

> "attempts to remedy the gaps [between theory and practice] by introducing problem-based or integrated approaches that are designed to bridge these gaps are entirely misguided...any approach that transforms problems into a series of theoretical questions merely deprives the problems of their essentially practical character and thereby misconceives the purpose of the whole enterprise" (1995:36).

For a curriculum model to meet the demands made by Margetson and Carr, theory should not be conceived as:

- separate from practice;
- derived from practice;
- considered in relation to practice; or
- applied to practice

Instead, practitioners (including students beginning to practice) should engage in actions (both of a practical and a theoretical nature) which "critically reconstruct" their practice: not simply the practical actions of their practice, but their theoretical actions (their "theorising") associated with their practice.

In attempting to explain the findings of this study, it seems reasonable to suggest that for the pre-clinical students (both those undertaking the PBL and the LBC courses), theory and practice remain distinct, and that neither group engaged in practical reasoning. However, it may be that the clinical students were able to reason in this way, although the evidence does not conclusively indicate that they did so. Even so, the fact that they might have engaged in practical reasoning is probably more due to 'other' educational factors (such as their own clinical experience and their reflections on this) than the PBL arrangement of the curriculum.

In summary, this chapter has undertaken a comprehensive review of literature, regarding five closely-related topics which have a bearing on the process of medical education. These topics are namely: experiential, reflection, knowledge, practice and theory. The various definitions of each topic have been noted and the major features described, including the implications on curriculum planning. One of the major issues examined throughout the literature is the integration between practice and theory and how they link together to affect student learning.

In the next chapter, an alternative model, ‘practice and experiential-based learning’ (PEBL), will be presented. This is derived from, and attempts to satisfy, the theories of Margetson and Carr.

Section VI: Recommendations and Suggestions for Further Research

Chapter Ten

Recommendation I: Practice and Experiential-Based Learning Model (PEBL)

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10.1 Introduction

In recent years, there has been a huge shift from teacher-centred learning to student-centred learning (Tan O., 2007). This study has focused on student-centred learning in the educational strategies of planned medical education curricula (Dolmans et al, 2005, Tan O.S., 2007) via PBL. However, the research gave a surprising result: for Saudi pre-clinical students, PBL did not have the positive effect predicted by the literature, whilst it did for clinical students.

In Chapter Eight it was argued that the reaction of the PBL students was what might have been expected of students in a conventional curriculum. Overall, this result was interpreted in terms of Margetson's (1999) notion of a fundamental "misconception" of pre-clinical teaching as separating understanding from action. Virtually every undergraduate medical curriculum distinguishes the two in considering that understanding is theory and action is practice. The terms "pre-clinical" and "clinical" are practical manifestations of this opinion. In Chapter Nine, this view was given considerable support by other educational writers, notably in Carr's analysis of the relationship between theory and practice.

The fundamental misconception of a separation between theory and practice not only helps explain why the Saudi pre-clinical students were so negative towards PBL but also seriously questions any curriculum which separates understanding from action - even another problem-based one. In this chapter, a model for a curriculum, called Practice and Experiential-Based Learning (PEBL), is described. The fundamental basis for this model is the way it deals with the relationship between theory and practice and how it encourages "practical reasoning".

This study has shown that, whilst clinical students are in favour of PBL, pre-clinical students are not. Since this may be explained by the gap in traditional curricula between theory and practice, the PEBL model that has been developed through this study is a modified version of PBL, outlined as an educationally recommended strategy for Saudi medical students that will reduce this gap and therefore improve the learning experience at both pre-clinical and clinical stages.

Therefore, PEBL is a form of learning that is rooted in learners and in their learning through experience. It features hands-on clinical experience throughout the curriculum, provides the professional skills needed for students to see the relationship between theory and practice and provides a means for improving the healthcare of Saudi patients by being relevant to their needs. In PEBL, the professional practice of medicine provides a basis for understanding the principles of health and disease in and through relevant action. This encourages students to develop competence, experience and communication skills through continuing practice in the clinical setting by introducing them to learning in the context of appropriate forms of active clinical practice, and by critical deliberation of that practice and the theory underpinning it.

10.2 A description of Practice and Experiential-Based Learning (PEBL)

According to the results of this study, a new model was invented that would suit Saudi medical education and would have the elements necessary in order to help pre-clinical and clinical students in accommodating other education strategies (including PBL). This model is named Practice and Experiential-Based Learning (PEBL), and engages students in first-hand experience of practice from the very beginning of the curriculum. It has three components: Practice (P), Theory (T) and Link (L) (see tables 10.1 and 10.2).

Table 10.1 Practice and Experiential-Based Learning (PEBL) model components

COMPONENT	PURPOSE	ACTIVITIES
Practice [P]	• To provide experience in community and hospital settings as a basis for learning theory	• Observation of medical practice in action • Clinical skills laboratories • Clinical case-based activity • Interviewing patients, home visits • Scientific practical laboratories
Link [L]	• To enable students to link practice and theory through engaging them in "practical reasoning"	• Portfolio • Journals • Group work (with tutors) • Student/doctor conversations • Student/student conversations • Independent study
Theory [T]	• To help students understand what is happening in practice through knowledge, concepts, facts etc., and begin to develop a knowledge-base to enable them to practise effectively	• PBL procedures – discussing cases (chosen cases and the students' own clinical experiences) • Carefully targeted formal teaching; lectures, seminars, tutorials, laboratory discussion

Table 10.2 Practice and Experiential-Based Learning (PEBL) model component relationships distributed over the six-year course

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
P	**PRACTICE**					
	Primary Healthcare *Community-based*			*Secondary/Tertiary Healthcare* *Hospital-based*		
⇨ **L**	⇳	⇳	⇳	⇳	⇳	⇳ ⇨
T	**THEORY**					
	Scientific Concepts	*Medical Scientific Concepts*		*Medical Specialty Concepts*		
Current Stages	"Basic" Scientific Stage	"Pre-clinical" Stage		"Clinical" Stage		

10.2.1 The practice [P] component

The practice component is defined as the setting where the students experience the practice of medicine and acquire, create and use theoretical concepts to enable them to understand that practice throughout the six-year course (see table 10.2).

"Basic" (year one) and "pre-clinical" students (years two and three) would experience practice in a *community setting*. This would include work in primary healthcare centres and dispensaries, work on various projects, including community surveys and family assignment projects, and work in different kinds of communities (rural, suburban or urban). "Clinical" students (years four to six) would experience practice in a *secondary/tertiary hospital setting* - participating in bedside medicine and emergency care. However, the emphasis should not exclusively be on learning in a teaching or highly-specialized hospital. The hospital-based experience would be related to primary care to enable the students to distinguish between, and relate to, the different levels of the healthcare system.

The purpose of the practice component of the curriculum is to provide students with the experience of practicing in community and hospital settings. The practical activities covered by the student would include clinical skills (such as taking blood pressure measurements), scientific practical laboratories (such as anatomy and pathology), case-based laboratories (simulated patient or paper problems), and also experience and training in patient interviews and home visits. In particular, students would observe the practice of doctors engaging in their normal work, and so would engage in the clinical practice that was appropriate to the stage of the curriculum that they were in.

10.2.2 The theory [T] component

The theory component of the PEBL model includes the scientific concepts which enable students to understand their actions (and those of doctors). By understanding the theory, students can begin to develop a knowledge base which will enable them to practise effectively. Students would engage in a number of activities to achieve these goals.

Firstly, students would engage in problem-based learning (PBL). PBL is a vehicle for enabling students to develop a usable body of integrated knowledge and problem-solving skills (Amin and Khoo, 2003). It involves tackling patient problems, health delivery and basic medical sciences problems, which act as a stimulus for student learning (Tan, 2003). Students would deal with the problems of individuals as well as with community problems (Hamilton, 2005); problems chosen would be directly related to those experienced by the students in the practice component of the curriculum. In this way, PBL would meet Margetson's (1999) criteria for being "rigorously problem-based", and would reflect Barrow's (1994) notion of practice-based learning. Students would also engage in a variety of additional educational activities chosen to develop their theoretical understanding, including seminars, lectures and special laboratory discussions. The content of this teaching (and of any assessments of students' learning) would be entirely relevant to the purpose of enabling students to understand their practice.

As the largest portion of students' time would be devoted to self-directed learning (see below), PEBL students would learn to critically assess learning resources and the theory they were acquiring for adequacy, quality and veracity. PEBL students would also be encouraged to see their peers as an invaluable source of information - to collaborate with them in learning issues and to share information and tips on resources which they have found helpful. They would also utilize learning resources such as libraries and audio-visual materials in order to help them understand medical phenomena from a more conceptual perspective (Dornan, Hadfield et al., 2005, Littlewood et al., 2005).

10.2.3 The link [L] component

The link component defines the curricular structures that encourage students to integrate practice with theory in the way that Carr describes as "practical reasoning". Students would engage in a number of activities to "deliberate" the relationship between theory and practice in the practice of medicine. The methods for achieving this are outlined below.

Portfolios

Portfolios are personal records of students' learning which aid self-direction and integration of knowledge (Corcoran and Nicholson, 2004). They can also enable assessment of students' learning to be undertaken in a qualitative manner, as Pitts (2007: 23) states:

> "Portfolios involve a movement from summative to formative evaluation and from a product orientation stressing quality control/standards to a learner-centred emphasis stressing student development and teacher decision-making as well as a shift in power relationships (from externally controlled assessment to responsive evaluation) and cultural sensitivity."

In this way, portfolios can be an effective alternative to conventional testing. They enable teachers to assess students' learning on an ongoing basis, and thus to monitor any gaps in that learning and make any necessary curriculum decisions to ensure that the learning environment is a student-centred one. Unlike standard testing methods where the teacher remains objective, portfolio assessment necessitates that the teacher and student build a close working relationship, with the teacher observing and guiding the student's progress (O'Neill et al., 2002; Dornan et al., 2005; Dornan, Hadfield et al., 2005; Dornan TL, 2006; Dornan et al., 2007).

Journals

The use of journals (or log books) is another activity which encourages students to reflect. Students write down their daily learning activities, which "involves learners in actively processing their learning" (Al-Kuwaiti, 1996; Fish and Coles, 2005).

Group work

Group work focuses on interactions between students and their tutor. The tutor acts as a facilitator to guide students' learning which in turn encourages and motivates them more generally in their other learning activities.

Discussion/Conversations

Student/doctor conversations encourage deliberation in the clinical setting, as do student/student conversations, in which students are encouraged to discuss with each other what they are learning.

Independent Study

Independent learning is an activity which gives students greater autonomy over their choice of subject matter, learning methods, pace of study and learning outcome.

Reflection

The fundamental basis of deliberation is that it encourages reflection on learning, both on process and content. This can help students take charge of and become more involved in their learning (even in highly constraining circumstances) (Fish and Coles, 2005). Reflection can be particularly important in the context of professional working as it can help turn experience into learning. Reflection emphasizes two elements. Firstly, it emphasizes learner activity because it involves learners in actively processing their learning. Secondly, reflection emphasizes the development of a well-structured knowledge-base, through making students' own knowledge - and the gaps in that knowledge - more apparent to them.

Learner support

The link component of the curriculum serves a crucial function as it provides opportunities for deliberation by students concerning the inter-relation between theory and practice. To achieve this, students need support for their learning skills as they may be passive and take a superficial approach through the use of habitual study skills developed in a context where a rote learning approach might be considered sufficient. Study skills alone are not sufficient, as most skills can be used to implement either a superficial or a deeper approach to studying. However, it is important to develop *learning* skills, in the context of developing an understanding of their purpose, an awareness of task demands, and flexibility in adapting to different demands (Al-Kuwaiti, 1996; Dornan et al, 2007).

Skilled learners are more in control of their learning and thus experience a greater ownership of their learning; this enhances motivation accordingly. They are also likely to process subject matter in a more active and varied way. The development of learning skills involves special exercises (Al-Kuwaiti., 1996) so reflection on learning needs to be integrated into each course and task that the students undertake. The college will need to consider how best to prepare students' study skills perhaps as part of the foundation course or as ongoing workshops throughout the course (O'Neill et al, 2002; Littlewood et al, 2005; Dornan et al, 2005).

Teacher support

The skills of reflection and deliberation must be reinforced by all teachers and doctors in practice. To achieve this there needs to be a program of "teacher development" which includes topics such as "How to encourage appropriate learning approaches by our students".

10.3 Summary

In this chapter, the notion of Practice and Experiential-Based Learning (PEBL) has been introduced as a recommended model to be used by the colleges of medicine. PEBL has three components: Practice (P), Theory (T) and Link (L). Practice provides experience as a basis for theory both in a community and a hospital setting. Theory helps students understand what is happening in practice, and enables them to begin to develop a knowledge-base for them to practise effectively. The Link component encourages students to deliberate on their practice and to construct theory by theorising. Various curricular structures have been described to achieve this proposal.

A procedure for implementing PEBL – based on the PDCA (Plan, Do, Check, Act) cycle adapted from the Shewhart cycle (Deming, 1986) – provides a rigorous means of maintaining the quality of the curriculum, and a continuous form of evaluation to ensure it is acted upon appropriately.

The next and final chapter will indicate limitations of the study and then highlight further research for future studies.

Section VI: Recommendations and Suggestions for Further Research

Chapter Eleven

Recommendation II: Limitations of the Present Study and Indications for Further Research

Chapter Eleven
Recommendation II: Limitations of the Present Study and Indications for Further Research

11.1 Introduction

In the previous chapter the PEBL model was outlined, providing a new way forward for medical education in Saudi Arabia. This has been generated from the current study, and has not yet been implemented; if PEBL, or something like it, were implemented it would first need investigation.

In the current chapter, recommendations are made from the conclusions of this study to aid not only further research in medical education, but also to aid the curriculum planners and the colleges of medicine in Saudi Arabia. The limitations of this study are noted as a basis for further research.

11.2 Limitations of the study

Certain limitations of this study are outlined below.

1. The scope of the study

This study was limited to the students at the college of medicine in Saudi Arabia, who were enrolled on certain courses across the curriculum. In the pre-clinical program, all students in MDPA 306 (General Pathology) were study subjects, while in the clinical programme, in FAMCO 454 (Primary Health Care), MDMD 451 (Internal Medicine), MDPM 517 (Clinical Pharmacology), MDPY 508 (Psychiatry), MDPD 554 (Paediatrics), MDOG 553 (Obstetrics and Gynaecology), MDMD 501 (Internal Medicine) were study subjects, covering the whole of the curriculum.

2. Spectrum of courses in the study

This study was conducted on a few scattered courses in the curriculum. As noted in Chapter Four, the conventional curriculum was running in parallel with the PBL courses. There may have been complex interaction and contamination effects. These would limit the ability to draw general conclusions from the results obtained.

3. Tools used for data collection

The use of a self-completed questionnaire, rather than direct observation of students in practice by a trained observer, does not give information about actual behaviour. The presence of an LBC control group encourages the assumption that it may actually be the process of the course that has led to the attitudinal changes measured.

4. Background of tutors

Generally, the faculty members serving as facilitators were well trained as educators for the purposes of this study. However, their knowledge of problem-based learning techniques remained quite variable. Smith and McGahie (1984) identified six distinct problems in evaluation by teachers/facilitators, one of these being "lack of preparation of faculty for their educational roles." Thus, the variability among the instructors might be of greater magnitude than that seen in standard instructional situations (though this does not account for the differences found between pre-clinical and clinical PBL students).

5. Tutor knowledge and attitude assessment

This study did not assess the knowledge of the tutors and their attitude regarding PBL.

6. Tutor involvement

Tutor evaluation was not included in this study, but the tutors' perceptions were studied.

7. Random assignment of students

The random assignment of students should have produced equivalent groups, although there may still be some differences between groups due to the presence and interaction of different characters within each group. Furthermore, seven students had to be reassigned (three pre-clinical and four clinical students). This is a small proportion of the total number of students participating, but it is proper to ensure that the possible lack of equivalence did not influence the results. In order to do this the GLM analysis reported earlier were all repeated with controls for pre-test results. These are reported in Appendix E and confirm the findings that were found without controls.

11.3 Recommendations for future research and implementation

The findings from this investigation suggest a need for additional research to develop PBL for undergraduate medical students. Recommendations are as follows:

1. This study, and other PBL research, depends heavily on the perceptions of students and tutors for insights into their experience. Validation and reliability studies on perceptually-generated data would enhance internal validation and allow conclusions to be based on more secure empirical evidence.

2. Responses to the open-ended questions supported contentions based on quantitative data and provided further insight to these contentions or demonstrated the presence of relationships not apparent from analyses of numeric replies. Therefore, an investigation into students' feelings, concerns, and ideas about PBL should be undertaken through additional qualitative research (especially observation studies and interviewing).

3. The PBL process generates a variety of process-oriented data. Although research has been started here on the use of learning issues to determine problem effectiveness, further research on the other components and on relationships between such components is needed. In this study it has been noted that the "problems" that formed the basis of PBL were only "convenient pegs" for teaching pre-clinical theory and did not reflect pre-clinical students' "practice"

(largely because they had only limited experience of medicine at that stage). Further research into other PBL curricula might investigate by how much the "problems" used are perceived by students as "practical".

4. There should be a study at the Saudi colleges of medicine to investigate the impact of pre-university Saudi education on medical students. It has been shown in this study that PBL was not positively received by the pre-clinical students, in contrast to clinical students. Further studies, here or elsewhere, might look at "cultural" effects on PBL students' reactions to problem-based learning.

5. A further study should be conducted focusing on Saudi physicians who have taught a problem-based learning curriculum to investigate whether they have acquired different knowledge, attitudes and professional skills than those who had completed a traditional curriculum. Some of these studies might be undertaken quickly by identifying Saudi physicians educated at other PBL schools. Other studies, of a longer-term nature, need to be conducted to follow through the Saudi colleges of medicine students engaged in the current study.

6. A study should be conducted focusing on the Saudi colleges of medicine intending to offer a PBL course as a foundation year in which the student can be oriented to the requirements of the curriculum by means of extra teaching in study skills and learning skills and through exposure to other methodologies.

7. A study focusing on a longer-term research intervention might reshape Saudi secondary schools to be more like the sixth form centres of 'community colleges', giving the students a degree of control over how they choose to divide their study time, and to move away from authoritarian didacticism or pedagogical methods based on rote learning.

8. The current study has now created a group of students who have been randomly allocated to PBL at pre-clinical and clinical stages. A long-term study could assess

their study habits, perceptions of and approaches to PBL in two years, five years and ten years.

9. Finally, a major study should be undertaken in medical schools into Margetson's "misconception" (Chapter Eight) and Carr's notion of "practical reasoning" (Chapter Nine). This study has argued that there is a fundamental flaw in the "theory first" view that underpins much medical education. Such an enquiry needs to look at conventional curricula as well as innovative alternatives (including PBL). It should focus on the curricular activities of staff and students, and particularly on how practice and theory are perceived and understood. This should focus not just on the early (pre-clinical) years but also the later (clinical) ones. Knowledge acquisition and knowledge use in the practice setting should be a prime focus for data collection. It is likely that a combination of qualitative and quantitative techniques will be needed.

11.4 Summary

In this chapter, the limitations of the present study and indications for further research have been discussed. Above all, there is an urgent need for studies in medical education which investigate the serious questions raised here.

Until there is a greater understanding of the educational consequences of introducing "practical reasoning" into medical education, undergraduate students and postgraduate trainees are likely to be poorly served by those who plan and implement their educational programmes.

BIBLIOGRAPHY AND REFERENCES

Adams, C. (1986). Islamic Resurgence: Religion and Politics in the "Muslim World." *Cities of God: Faith Politics and Pluralism in Judaism, Christianity and Islam*,Biggar, N. et al. (eds). New York: Greenwood Press.

Adkinson, L. R., & Volpe, E. P. (1994). Increasing student exposure to medical genetics through a problem-based learning curriculum during the first two years of medical training. *Teaching and Learning in Medicine, 6(2): 128-131.*

Adsett, C. (1968). Psychological Health of Medical Students in Relation to the Medical Education Process. *Journal of Medical Education, 43:728.*

Ain-Al-Yaqeen Online Magazine (2001). *The Kingdom of Saudi Arabia Witnesses Huge Achievements and Development Projects.* Accessed July 20, 2007. Available; URL: http://www.ain-al-yaqeen.com/issues/20011123/feat8en.htm

Alexander, D. A. & Haldane, J. D. (1980). Medical Education: The Discontinuer's Viewpoint. *Medical Education, 14 (1):16-22.*

Al-Awdah, S., Lutfi, A.M. & Ibrahim, E. (1994). *The college of medicine and medical science (CMMS) at King Faisal University (KFU), Dammam, Saudi Arabia.* Paper presented to the World Federation of medical education planning conference and Deans' meeting, Alin, United Arab Emirates.

Al-Ankary, K. (1998). *Higher Education in the Twenty-first Century Vision and Action.* World Conference on Higher Education, UNESCO, Paris, V: 5-9.

Al-Farsy, F. (1990). *Modernity and Tradition the Saudi Equation: 1st Edition.* London, UK: Kegan Paul International Ltd.

Al-Gindan, Y. M., Al-Sulaiman, A. A. & Al-Faraiday, A. (2000). Undergraduate curriculum reform in Saudi Medical Schools, which direction to go? *Saudi Medical Journal, 21:324-326.*

Al-Gindan, Y. M. & Al-Sulaiman, A. A. (1998). Undergraduate curriculum reform in Saudi medical schools, needed or not? *Saudi Medical Journal, 19:229-231.*

Al-Khazim, M. A. (2006). *The Saudi Arabian higher education on scale.* Arabian printing and publishing house.

Al-Khazim, M. A. (2003). *Higher Education in Saudi Arabia: Challenges, solutions and opportunities missed.* Higher Education Policy, 16: 479-486.

Al-Kuwaiti, A., (1996). 'The learning skills of undergraduates: A proposal for Saudi medical education.' *Journal of Family and Community Medicine, 26(6): 570-573.*

Al-Kuwaiti, A. (2007). *Undergraduate Saudi medical education a review of literature and suggestion for reform.* Paper presented and published at the proceeding . Saudi Innovation Conference at Newcastle University., Newcastle upon Tyne, The United Kingdom. ISBN: 978-0-955104-92-3.

Al-Muhanna, F. (2000). *A revisit of undergraduate medical curriculum in the context of Saudi Arabia, King Faisal University.* A paper presented at the Second Guld Council Conference of Faculties of Medicine, Medical Education: Future Perspectives, Al-Khobar, Saudi Arabia.

Al-Muhanna, F. & Bella, H. (2006). *Health Services in Saudi Arabia-Future Perspective.* Dammam, Dar Al Salah Publishing Company.

Al-Muhanna, F. & Lutfi, A. H. (2002). *King Faisal University: College of Medicine, A Documentary.* King Faisal University Press, 19:508-509.

Al-Mulhim, A. & Al-Kuwaiti, A. (2002). The future of the curriculum of allied (applied) health sciences in Saudi Arabia. *Journal of Family and Community Medicine, 9(2):55-59.*

Al-Riyadh Online Newspaper. (2004). *The first scientific conference of the monarch of medical education in Saudi Arabia.* Accessed February 27,2007. Available; URL : http://www.alriyadh.com/local/10524. htm

Al-Shehri, M. Y. (2001). Medical curriculum in Saudi medical colleges: current and future perspective. *Annals of Saudi Medicine, 21:320-323.*

Al-Sebai, Z. A., & Cairncross, R. G. (1982). *Medical education in Saudi Arabia: Which way forward* (pp. 3-6). Paper presented at the sixth medical meeting at King Faisal University. Al-Ahsa, Saudi Arabia.

Al-Sibai,M.H., Al-Freihi, H. M., Lutfi, A. M.,Al-Mahaya, S. A., Magbool,G., & El-Mouzan, M. L. (1989). Evolution of the undergraduate curriculum at the College of Medicine, King Faisal University. *Annals of Saudi Medicine, 9: 64-71.*

Al-Umran, K. (1996). Undergraduate pedicatric education in Saudi Arabia: Time for reappraisal. *Middle East Pediatrics, 1(1):10-13.*

Albanese, M., & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine, 68:52-81.*

Albanese, M. (2000). Problem-based learning: why curricula are likely to show little effect on knowledge and clinical skills. *Medical Education, 34:729 – 738.*

Aldred, M. J., & Aldred, S. E. (1998). Problem-based learning: the good, the bad, and the ugly. *Journal of Dental Education, 62: 650-655.*

Aldred, S.E., Aldred, M.J., Walsh, L.J., & Dick. B. (1998). Implementing problem-based learning into professional and dental education. *Journal of Dental Education, 62: 644 – 649.*

Alleyne, T., Shirley, A., Bennett, C., Addae, J., Walrond, E., West, S., & et al. (2002). Problem-based compared with traditional methods at the Faculty of Medical Sciences, University of the West Indies: A model study. *Medical Teacher, 24(3): 273 – 279.*

Amin, Z., & Khoo, H. (2003). *Basics in Medical Education. Singapore.* World Scientific Publishing Co. Pte.

Anderson, J., & Graham, A. (1980). A Problem in Medical Education: Is there an information overload? *Medical Education, 14:4-7.*

Armstrong, E. G. (1991). *A hybrid model of Problem-Based Learning.* In D. Boud and G. Feletti (Eds), The Challenge of Problem-Based Learning. 137-147, London. Kogan Page.

Ausubel, D. P. (1968). *Educational Psychology: A cognitive view.* New York: Holt, Rinehart and Winston, Inc.

Azer, S. A. (2001). Problem-based learning, challenges, barriers and outcome issues. *Saudi Medical Journal, 22(5):389-397.*

Baca, E., Menin, S. P., Kaufman, A., & Moore-West, M. (1990). *Comparison between a problem-based learning, community-oriented track and a traditional track within one medical school.* In Nooman, Schmidt and Ezzat (eds). Innovation in Medical Education: An evaluation of its present status, New York: Springer Publishing Company, 9-27.

Balla, J. I., Biggs, J. B., Gibson, M., & Chang, A. M. (1990). The application of basic science concepts to clinical problem-solving. *Medical Education, 24:137-147.*

Barab, S., & Squire, K. (2004). Design-based research: putting a stake in the ground. *J Learn Sci, 13 (1):1-14.*

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning: an approach to medical education.* Series on Medical Education, New York, USA, Springer.

Barrows, H. S. (1986). A taxonomy of problem-based learning methods. *Medical Education, 20: 481-486.*

Barrows, H. S. (1988). *The tutorial process.* Springfield, Illinois: Board of Trustees, Southern Illinois University.

Barrows, H. S. (1994). *Practice-based learning applied to the medical curriculum.* Springfield, Illinois: University of Illinois Press.

Barrows, H. S. (1998). The essentials of problem-based learning. *Journal of Dental Education, 62(9): 630-3.*

Barrows, H. S. (2000). *Problem-based Learning applied to medical education.*Springfield, Southern Illinois University, School of Medicine.

Barrows, H. S. (1985). *How to design a problem-based curriculum for the preclinical years.* New York: Springer.

Bayard, B.L., (1994). *Problem based learning in dietetic education: a descriptive and evaluative study*, Ph.D.,Milwaki, Wisconsin: University of Wisconsin.

Beck, A. L., & Bergman, D. A. (1986). Using structured medical information to improve student problem-solving performance. *Journal of Medical Education, 61:749-756.*

Bell, J. (1999). *Doing your research project: A guide for first-time researchers in education and social sciences (3rd ed).* Buckingham: Open University Press.

Berkson, L. (1993). Problem-based learning: Have the expectation been met? *Academic Medicine, 68(10):579-88.*

Berliner, D. C. (2002). Educational research: the hardest science of all. *Educ Res, 31 (8):18-20.*

Berner, Eta S. (1984). Paradigm and problem-solving: A literature review. *Journal of Medical Education, 59:625-633.*

Bernstein, P., Tipping, J., Bercovitz., Skinner, H., (1995). Shifting Students and facualty to a PBL curriculum: Attitudes changes and lessons learned. *Academic Medicine, 70: 245-247*

Birch, W. (1986). *Towards a model for problem-based learning.* Studies in higher education, 11(1): 73-82.

Bligh, J. (2000). Problem-based learning: the story continues to unfold. *Medical Education, 34: 688 – 689.*

Blumberg, P., Michael, J., & Zeitz, H. (1990). Roles of student-generated learning issues in problem-based learning. *Teaching and Learning in Medicine, 2(3): 149-154.*

Blumberg, P., & Eckenfels, E. (1988). *A comparison of student satisfaction with their preclinical environment in a traditional and a problem based curriculum.* Proc Annu Conf Res Med Educ, 27: 60-65.

Bordage, G. (1987). The curriculum: overloaded and too general. *Medical Education, 21:183-8.*

Borg, W. R., & Gall, M. D. (1989). *Educational Research: An introduction.* New York: Longman.

Botelho, M.G. (1999). Embedded problem-based learning of a clinical subject. *British Dental Journal, 186(4): 192 – 195.*

Botelho, M. G. (1999). Embedded problem-based learning of clinical subject. *British Dental Journal, 186 (4):192-195.*

Boud, D., & Feletti, G. (Eds.). (1991). *The challenge of problem-based learning.* London: Kogan page.

Boyd, E. M., & Fales, A. W. (1983). Reflective learning: key to learning from experience. *Journal Humanistic Psychology, 23:99-117.*

Brandon, J., & Majumdar, B. (1997). An introduction and evaluation of problem-based learning in health professions education. *Family and Community Health, 20(1): 1 – 15.*

Bryman, A. (2004). *Social Research Methods (2nd ed).* New York: Oxford.

Browne, H. (2007). A model of experienced-based workplace learning. *The Clinical Teacher, 4:112-115.*

Bruner, E. S. (1960). *The process of education.* Cambridge, Massachusset: Harvard University Press.

Bureau of Near Eastern Affairs (2001). *Background Note: Saudi Arabia November2001.* US Department of State. Accessed May 30,2007.
Available: URL: http://www..state.gov/r/pa/bgn/index.cfm?docid=3584

Burnard, P., & Morrison, P. (1992). *Self-disclosure: A contemporary analysis.* Avebury, Aldershot.

Burns, R. B. (2000). *Introduction to Research Methods (4th ed).* London: Sage Publishers.

Cameron, J., et al. (1983). *The International Handbook of Education System: United Kingdom.* John Wiley and Sons.

Carr, W. (1995). *For education: towards critical educational inquiry.* Buckingham: Open University Press.

Chamberlain, S.E., & Searle, J. (2005). Assessing suitability for a problem-based learning curriculum: evaluating a new student selection instrument. *Medical Education, 39: 250 – 257.*

Childs, B. (1990). Genetics for medical students. *American Journal of Human Genetics, 41: 296-303.*

Claessen, H. F. A., & Boshuizen, H. P. A. (1985). Recall of medical information by students and doctors. *Medical Education, 19:61-67.*

Clare, B., & Feltham, W. (1990). Facilitating Peer Group Teaching within Nurse Education. *Nurse Education Today, 10:54-57.*

Coe, R. (2000). *What is an effect size? A guide for users.* On line articles. Accessed February 17, 2007.
Available: http://www.cemcentre.org./ebeukresearch/Effectsize/esguide.htm

Cohen, L., Marion, L & Marison, K. (2001). *Research Methods in Education (5th ed).* London: Routledge Falmer.

Cohen, L., Manion, L. (1989). *Research Methods in the Educational Research.* London, Croom Helm.

Colby, K. K., Almy, T. P., & Zubkoff, M. (1986). Problem-based learning of social sciences and humanities by fourth-year medical students. *Journal of Medical Education, 61: 413-415.*

Coles, C., (1985a). Difference between conventional and problem-based curicula in their student's approach to studying. *Medical Education, 19: 308-309*

Coles, C., (1985b). *A study of the relationship between curriculum and learning in undergraduation medical education*, Ph.D., dissertation: University of Southampton, School of Education, Southampton, U.K.

Coles, C.R., (1990a). Elaborated learning in undergraduate medical education. *Medical Education 24: 14-22*

Coles, C. (1990b). *Is problem-based learning the only way?* In D. Boud and G, Felleti (eds) the challenge of problem-based learning. London: Kogan page.

Coles, C. (1998). *How students learn: the process of learning.* In: B Jolly, L Rees, eds. Medical Education in the Millennium. Oxford: Oxford University Press.

Colliver, J.A. (2000). Effectiveness of Problem-based learning curricula: Research and Theory. *Academic Medicine, 75(3): 259 – 266.*

Collin, A. (1994). *Goal-based scenarios and the problem of situated learning: A commentary on Adnersen consulting design of goal-based scenarios.* Educational Technology, 12:30-33.

Colliver, J. A. (2001). Are qualitative studies of the PBL tutorial process indicated? *Academic Medicine, 76: 215-216.*

Colliver, J. A., & Markwell, S. J. (2007). Research on Problem-Based Learning: The Need for Critical Analysis of Methods and Findings. *Medical Education, 41:533-535.*

Corcoran, J., & Nicholson, C. (2004). Learning portfolios-evidence of learning: an examination of student's perspectives. *Nursing Critical Care, 9(5):230-237.*

Cordesman, A. (2001a). *Saudi Arabia enters the 21st century: V. Building True Wealth versus Over-dependence on Petroleum and State.* Washington, DC, USA, Center for Strategic and International Studies.

Cordesman, A. (2001b). *Saudi Arabia enters the 21st century: Economic, Demographic, and Social Challenges.* Washington, DC, USA, Center for Strategic and International Studies.

Cowan, J., & Garry, A. (1986). *Learning from Experience.* Further Education Unit, London.

Creedy, D., & Hand, B. (1994). The implementation of problem-based learning: changing pedagogy in nurse education. *Journal of Advanced Nursing, 20: 696-702.*

Curry, J. (1991a). *A guide to the development of problem based learning modules.* Columbus, Ohio, The Ohio State University, College of Medicine.

Curry, J. (1991b). *The Facilitator's Guide to small group process.* Columbus, Ohio: The Ohio State University, College of Medicine.

Dahle, L.O., Forsberg, P., Svanberg-Hard, H., Wyon, Y., & Hammar, M. (1997). Problem-based medical education: development of a theoretical foundation and a science-based professional attitude. *Medical Education, 31: 416 – 424.*

Dammers, J., Spencer, J., & Thomas, M. (2001). Using real patients in problem-based learning: students' comments on the value of using real, as opposed to paper cases, in a problem-based module in general practice. *Medical Education, 35:27-34.*

Darnton, R. (2006). Crossing the PBL divide: from PBL medical student to medical teacher. *Medical Teacher, 41:222-225.*

Davidson, R. G., & Childs, B. (1987). *Perspectives in the teaching of human genetics.* In Harris, H. & Hirschhorn, K. (Eds.), Advances in human genetics, 16: 75-119.

Davis, S. S. (1994). *Problem-Based Learning in Medical Education: A qualitative study of curriculum design and students' experience in an experimental program.* PhD Thesis: Ohio State University, Ohio, United States of America.

Davis, W. K., Nairan, R., Paine, M. E., Anderson, R.M., & Oh, M. S. (1999). Effects of expert and non-expert facilitators on the small group process and on student performance. *Academic Medicine, 67:470-4.*

De Cossart, L. & Fish, D. (2004). *Membership of a Profession: Part II: The Nature of Professional Knowledge in Medical Practice.* Mersey Deamery. Newsletter, 14:2.

Desforges, G. (2000). *Familiar challenges and new approaches: Necessary advances in theory and methods in research on teaching and learning.* Notts: British Educational Research Association (BERA).

De Grave, W. S., Boshuizen, H.P.A., & Schmidt, H. G. (1996). *Problem-based learning: cognitive and metacognitive processes during problem analysis.* Instruct Science, 24:321-41.

De Grave, W. S., Dolmans, DHJM., & van der Vleuten. (1999). Profiles of effective tutors in PBL: scaffolding student learning. *Medical Education, 33:901-6.*

Des Marchais, J. E., Bureau, M. A., Dumais, B., & Pigeon, G. (1992). From traditional to problem-based learning: a case report of complete curriculum reform. *Medical Education, 26: 190-199.*

Des Marchais, J. E. (1991). *From traditional to problem-based curriculum: how the switch was made at Sherbrooke, Canada.* Lancet, 338: 234-237.

Deming, W. E. (1986). *Out of the Crisis,* MA: MIT Press.

DeVellis, R. (1991). *Scale development: Theory and applications.* California, U.S.A., Sage Newbury Park.

De Volder, M. L., & De Grave, W. S. (1989). Approaches to learning in a problem-based medical programme: a developmental study. *Medical Education, 23: 262-264.*

Dewey, J. (1971). *Experience and education.* New York, Collier MacMillan.

Dias, A. (2006). Is problem-based learning causing a decline in medical knowledge. *The Clinical Teacher, 3:198-201.*

Dietrich, A. J., Moore-West, M., Palmateer, D. R., Radebaugh, J., Reed, S., & Clauson, B. (1990). Adapting problem-based learning to a traditional curriculum: teaching about prevention. *Fam Pract Res J, 10: 65-73.*

Dillenbourg, P., Baker, M., Blaye, A., & O'Malley, C. (1996). *The evolution of research on collaborative learning.* In: Spada E, Reiman, P, eds. Learning in Humans and Machines: Towards an Interdisciplinary Learning Science. Oxford: Elsevier, 189-211.

Distlehorst, L. H., Dawson, E., Robbs, R. S., & Barrows, H. S. (2005). Problem-based learning outcomes: the glass half full. *Academic Medicine, 80:294-299.*

Dochy, F., Segers, M., Bossche van den P., & Gijbels, D. (2003). *Effects of PBL: a meta-analysis.* Learn Instruct, 13 (5):533-68.

Dolmans, D.H.J.M. (2003). The effectiveness of PBL: the debate continues. Some concerns about the BEME movement. *Medical Education, 37: 1129 – 1130.*

Dolmans, D., Gijselaers, W., Moust J., de Grave, W., Wolfhagen, I., & van der Vleuten, C. (2002). Trends in research on the tutor in problem-based learning: conclusions and implications for educational practice and research. *Medical Teacher, 24(20): 173 – 80.*

Dolmans, D., de Grave, W., Wolfhagen, I., & van der Vleuten, C. (2005). Problem-based learning: Future challenges for educational practice and research. *Medical Education, 39: 732-741.*

Dolmans, D., Wolfhagen, I., & van der Vleuten, C. (2001). *Why aren't they working?* In: Schwartz, P., Mennin, S., Webb, G., eds. Problem-Based Learning. Case Studies, Experience and Practice. Case Studies of Teaching in Higher Education. UK: Kogan Page: 135-141.

Dolmans, D.H.J.M., Wolfhagen, H.A.P., Hoogenboom, R.J.I., & Van Der Vleuten, C.P.M. (1999). Is tutor performance dependent on the tutorial group productivity? Toward further resolving of inconsistencies in tutor performance. *Teach Learn Med, 11 (4):186-91.*

Dolmans, D.H., Snellen-Balendong, H., Wolfhagen, H., & Van Der Vleuten, C., (1997). Seven principles of effective design for a problem-based curriculum. *Medical Teacher, 19(3):185–9.*

Dolmans, D., & Schmidt, H. (1996). The advantages of problem-based curricula. *Postgraduate Medical Journal, 72: 535-538.*

Dolmans, D., Gijselaers, W., Schmidt, H., Van Der Meers, S., (1993) Problem effectiveness in a course using problem-based learning. *Academic medicine, 60: 207-213.*

Donner, R. S., & Bickley, H. (1990). *Problem-based learning: an assessment of it's feasibility and cost.* Human Pathology, 21:881-885.

Dorcas, A., & Cheng, L. A. (1999). *Learning styles and personality factors in implementing problem-based learning (PBL) for Hong Kong Chinese postgraduate students.* In Themes and Variations in PBL [Conway, J., & Williams, A., eds], Australian Problem Based Learning Network, Australia: 50 – 58.

Dornan, T., Scherpbier, A., King, N., & Boshuizen, H. (2005). Clinical teachers and problem-based learning: a phenomenological study. *Medical Education, 39: 163 – 170.*

Dornan, T. L. (2006). *Experience-based Learning. Learning Clinical Medicine in Workplaces.* Maastricht: Universitaire Pers Maastricht, 9-40.

Dornan, T., Boshuizen, H., & King, N. (2007). Experience-based learning: A model linking the processes and outcomes of medical students' workplace learning. *Medical Education, 41:84-91.*

Eagle, C. J., Harasym, P. H., & Mandin, H. (1992). Effects of tutors with case expertise on problem-based learning issues. *Academic Medicine, 67: 465-469.*

Echt, R., & Chan, S. (1977). A new problem-oriented and student-centreed curriculum at Michigan State University. *Journal of Medical Education, 52: 681-683.*

Eisenstaedt, R. S., Barry, W. E., & Glanz, K. (1990). Problem-based learning: cognitive retention and cohort traits of randomly selected participants and decliners. *Academic Medicine, 65: Suppl-2.*

El-Hazmi, M.A., (1993). Genetic diseases in Saudi Arabia - A model for national awareness and care programmes. *Saudi Medical Journal, 14 (6):570.*

El-Hazmi, M. & Tekian, A. (1996). A medical curriculum appraisal – Riyadh 6 days experience. *Medical Teacher, 8(1):55-63.*

El-Muzan, M.I., Lutfi, A.M., Absood, G.H., (1991). Secondary School and College admission test scores as predictors of performance of medical students in pre medical subjects. *Saudi Medical Journal, 12 (6): 477-480*

El-Shazli, H. (2002). Innovative medical education present status in the Arabian Gulf. *Arabian Gulf University Journal, 5:46.*

Elstein, A. S., Shulman, L. S., & Sprafka, S. A. (1978). *Medical problem solving: An analysis of critical reading* (p. 178). Cambridge, Massachusset: Harvard University Press.

Engel, C. E. (1991). *Not just a method but away of learning. In the challenge of problem-based learning.* Boud, D., and Felletti, G. Kogan Press.

Entwistle, N. J., & Ramsden, P. (1983). *Understanding student learning.* Croom Helm, London, United Kingdom.

Eraut, M. (1994). *The Development of Professional Knowledge and Competence.* Lewes:Falmer Books.

Eraut, M., & duBoulay, B. (2000). *Developing the attributes of medical professional judgment and competence.* Date accessed, April 4, 2007. Available: URL: http://www.cogs.susx.ac.uk/users/bend/doh/report html. Brighton: University of Sussex.

Ertmer, P.A., & Newby, T.J., (1993). *Behaviorism, cognitivism, constructivism: comparing critical features from an instructional design perspective.* Perform Improve Q, 6 (4):50-72.

Ertmer, P.A., & Newby, T.J. (1999). *The expert learner: strategic, self-regulated, and the reflective.* Instruct Sci, 24:1-24.

Farrow, R. & Norman, G. (2003). The effectiveness of PBL: the debate continues. Is meta-analysis helpful? *Medical Education*, 37:1131–2.

Ferguson, D. B. and Rutishauser, S. C. (1997). A problem-based preclinical course for dental students. *British Dental Journal*, 182: 387-392.

Fish, D., & Coles, C. (2005). *Medical Education: developing a curriculum for practice.* London Open University Press.

Flexner, A. (1910). *The Flexner report on medical education in the United States and Canada.* New York: Carnegie Foundation.

Fraenkel, J. R., & Wallen, N. E. (2006). *How to design and evaluate research in education.* New York: McGraw Hill Company.

Freidson, E. (1971). *Profession of Medicine: A Study of Sociology of Applied Knowledge.* New York: Dodd, Mead and Co.

Freire, P. (1972). *Pedagogy of the Oppressed.* Harmondsworth, Penguin.

Gagne, R. M., Briggs, L. J., & Wager, W. W. (1988). *Principles of instructional design (3rd ed).* New York: Hot, Rinehart and Winston, Inc.

Gall, M., Borg, W., Gall, J. (1996). *Educational Research, an Introduction (6th ed).* U.S.A., Longman Publishers.

Gay, L. R. & Airasian, P. (2000). *Educational Research Competences for Analysis and Application (6th ed).* Ohio, U.S.A., Prentice Hall.

Gay, L. R. & Airasian, P. (2003). *Educational Research Competences for Analysis and Application (7th ed).* New Jersey, Merril Prentice Hall.

General Medical Council (1993). *Tomorrow's Doctors: Recommendations on undergraduate medical education issued by the Education Committee of the General Medical Council in pursuance of section 5 of the medical act 1983.* London: General Medical Council.

General Medical Council. (2002). *Tomorrow's Doctors: Recommendations on Undergraduate Medical Education.* London: General Medical Council.

Gijbels, D., Dochy, F., & Seqero, M. (2005). *Effects of problem-based learning: a meta-analysis from the angle of assessment.*

Gillian, M. (1999). Roles and responsibilities of the problem-based learning tutor in undergraduate medical curriculum. *British Medical Journal*, 318:657-61.

Gilkison, A. (2003). Techniques used by 'expert' and 'non-expert' tutors to facilitate problem-based learning tutorials in an undergraduate medical curriculum. *Medical Education, 37: 6 – 14.*

Glaser, R. (1991). *The maturing of the relationship between the science of learning and cognitiion and educational practice.* Learn Instruct, 1:129-44

Golby, M., & Parrott, A. (1999). *Educational Research and Educational Practice.* Exeter, Fairway Publication.

Graham, J. M., Jr., Rotter, J. I., Riccardi, V. M., Baird, P. A., Benkendork, H., Bodurtha, Childs, B. (1989). Report of the task force on teaching human genetics in North American medical schools. *American Journal of Human Genetics, 44, 161-165.*

Hafler, J. P. (1991). *Case Writing: Case writer's perspectives.* In D. Boud & G. Feletti (Eds), The Challenge of Problem-Based Learning, (150-158). London: Kogan Page.

Hamilton, J. (2005). Problem-based Learning: from where to where? *The Clinical Teacher, 2(1):45-48.*

Hammad, M. (1973). *The Educational System and Planning for Manpower Development in Saudi Arabia.* Unpublished PhD Thesis, USA, Indiana University.

Harden, R.M., (1986). Ten questions to ask when planning a course or curriculum. *Medical Education, 20:356-365.*

Harden, R. M., Laidlaw, J. M., Ker, J. S. & Mitchell, H. E. (1996). AMEE Medical Education Guide No. 7. Task based learning: an educational strategy for undergraduate, postgraduate, and continuing medical education, Part 1. *Medical Teacher, 18(1): 7-13.*

Harden, R. M., Laidlaw, J. M., Ker, J. S. & Mitchell, H. E. (1996). AMEE Medical Education Guide No. 7. Task based learning: an educational strategy for undergraduate, postgraduate, and continuing medical education, Part 2. *Medical Teacher, 18(2): 91-98.*

Harden, R. M., Crosby, J., Davis, M. H., Howie, P. W., & Struthers, A. D. (2000). Task-based learning: the answer to integration and problem-based learning in the clinical years. *Medical Education, 34:391-7.*

Harris, R., Johnson, A. W., Harris, H. J., & Young, I. (1990). *Teaching genetics to medical students.* London: Royal College of Physicians. Report on the Working Party on Undergraduate Medical Education.

Heller, M., & Safran, N. (1985). *The new middle class and regime stability in Saudi Arabia.* Harvard, USA, Harvard Middle East Papers.

Hendry, G.D., Ryan, G., & Harris, J. (2003). Group problems in problem-based learning. *Medical Teacher, 25 (6):609-16.*

Heron, J. (1986). *Six category intervention analysis, 2nd (Ed)., Human Potential Resource Group.* University of Surrey, Guildford.

Heuther, C. A., (1990). Non traditional pedagogy for implementing human genetics education. *American Journal of Human Genetics, 44(1):596-599.*

Hill, D. A., (1997). A strategy for teaching and learning in the PBL clerkship. *Medical Teacher, 19, 24-28.*

Hitchcock, M.A., & Anderson, A.S. (1997). Dealing with dysfunctional tutorial groups. *Teach Learn Med, 9 (1): 19-24.*

Hmelo-Silver, C.E. (2004). Problem-based learning: what and how students learn. *Educational Psychology Review, 16 (3) :235-66.*

Janin, H. (1994). *Cultures of the World Saudi Arabia.* New York, USA, Marshall Cavendish Corporation.

Jarvis, P. (1991). Reflective practice and nursing. *Nurse Education Today, 12:174-181.*

Jayawickramarajah, P.T., (1996). Problems for problem-bsed learning: a comparative study of documents. *Medical Education, 30: 272-282.*

Johansen, M. L., Martenson, D. F., & Bircher, J. (1992). Students as tutors in problem-based learning: does it work? *Medical Education, 26: 163-165.*

Johnson, D. & Johnson, R. (1987). Using cooperative learning strategies to teach nutrition. *Journal of the American Dietetic Association, 87(9)(Suppl. S): 55-61.*

Johnson, S. & Finucane, P. (2000). The emergence of problem-based learning in medical education. *Journal of Evaluation in Clinical Practice, 6 (3): 281-291.*

Kagan, C., Evans. J., & Kay, B. (1986). *A manual of interpersonal skills for nurses: An experiential approach.* London, Harper and Row.

Kamin, C. (1995). *A curricular analysis of Problem-Based Learning in Medical Education.* Ph.D Dissertation: University of Houston, Faculty of the College of Education, Houston, United States of America.

Kaplan, A. (1973). *The Conduct of Inquiry.* Aylesbury: Intertext Books.

Kassab, S., Al-Shboul, Q., Abu-Heijelh, M., & Hamdy, H. (2006). *Teaching styles of tutors in a problem-based curriculum: students and tutors' perception.* 28(5):460-464.

Kassimi, M.A. (1983). Problems of Undergraduate Medical Education in Saudi Arabia. *Medical Education, 17: 23 – 25.*

Kassirer, J., & Kopelman, R. (1991). *Cases that teach clinical reasoning.* Hospital Practice, 26(1): 29-36.

Kaufman, D. M., & Mann, K. V. (1996). Comparing students' attitudes in problem-based learning. *Academic Medicine, 71:1096-9.*

Kaufman, D.M. (2000). Problem-based learning – Time to step back? *Medical Education, 34, 509 – 511.*

Kitty, J. (1982). *Experiental Learning. Human Potential Research Project.* Guildford, University of Surrey.

Khoo, H. E., Chhem, R.K., Gwee, M.C., & Balasubramaniam, P. (2001). *Introduction of problem-based learning in a traditional medical curriculum in Singapore – students' and tutors' perspectives.* Annual Academic Med Singapore, 30(4): 371-4.

Khoo, H. E. (2003). Implementation of problem-based learning in Asian medical schools and students' perceptions of their experience. *Medical Education, 38(5): 401-9.*

Kirschner, P., Sweller, J., & Richard, E. C. (2006). *Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching.* Educational Psychologist, 4(2):75-86.

Koberg, D., & Bagnall, D. (1981). *The revised all new universal traveler: A soft systems guide to creativity and problem solving and the process of reaching goals.* Kaufmann, Los Altos, California.

Kolb, D. A. (1984). *Experiential Learning: Experience as the source of learning and development.* Englewood Cliffs, New Jersey, Prentice-Hall.

Koschmann,T., Glenn, P., & Canlee, M. (1997). *Analyzing the emergence of a learning issue in a problem-based learning meeting.* Medical Education online [serial online], Date accessed 24/9/07.
Available; URL: http://www.utmb.edu.meol.

Knowles, M. (1989). *Self Directed Learning.* New York, Cambridge Books.

Krakov, S., Preston, W., and Rubin, P. (1990). Effects of an oncology electives on first year medical students knowledge of attitude about cancer. *Journal of cancer education. 5: 43-49.*

Kufman, A., Menin, S., Waterman, R., Duban, S., Hansbarger, C., Silverblatt, H., Obenshain, S., Kantrowitz, M., Becker, T., & Samet, J. (1989). The New Mexico experiment: educational innovation and institutional change. *Academic Medicine, 65 (6):285-294.*

Kvale, S. (1996). *Interviews: An introduction to qualitative research interviewing.* London, Sage Publication.

Lambie, A. T., Maclean, C. M., & McGuire, R. J. (1981). The introduction of problem-based learning projects into a clinical correlation course in the first year of the Edinburgh medical curriculum. *Medical Education, 15: 209-215.*

Lam, T. P. (2006). *A study of curriculum reform in an Asian medical school and the implications for medical education.* Ph.D Thesis.

Lowry, S. (1993). What's wrong with medical education in Britain? *British Medical Journal, 305:1277-80.*

Lindeman, E. (1956). *The Democratic Man.* In Gessner, R. (Ed) Selected writings, Beacon Press, Boston.

Littlewood, S., Ypinazar, V., Margolis, S. A., Scherpbier, A., Spencer, J., & Dornan, T. (2005). Early practical experience and the social responsiveness of clinical education: systematic review. *British Medical Journal, 331:387-91.*

Long, D. (1997). *The Kingdom of Saudi Arabia.* Gainesville, Florida, USA, University Press of Florida.

Magzoub, M.E. (1993). *Studies in community based education.* Maastricht, The Netherlands: Network of community-orientated educational institutions for health sciences.

Manchester Undergraduate PBL curriculum. Date accessed, May 10, 2007. \
Available: URL: http://www.parable.man.ac.uk.

Manderson, W. G., & Sclare, A. B. (1973). *Mental Health Problems in a Student Population.* Health Bulletin, 31:233-239.

Margetson, D. B. (1999). The relation between understanding and practice in Problem-based Medical Education. *Medical Education, 33:359-364.*

Margetson, D. B. (2000). Depth of understanding and excellence of practice: the question of wholeness and Problem-based Learning. *Journal of Evaluation in Clinical Practice, 6(3):293-303.*

Marsick, V. J., & Watkins, K. E. (1990). *Informal and incidental learning in the workplace.* Routledge, London.

Martenson, D. (1993). Is *problem-based learning beneficial? A research overview.* Educacao Medica, 4:2-9.

Martinson, D., Myklebust, R., & Stalsberg, H. (1992). Implementing Problem-Based Learning within a lecture-dominated curriculum: Results and Process. *Teaching and Learning in Medicine, 4(4):233-237.*

Marton, F., Hounsell, D. J., & Entwistle, N. J. (1984). *The experience of learning.* Scottish Academic Press, Edinburgh.

Maudsley, G. (2002). Making sense of trying not to teach: an interview study of tutors' ideas of problem-based learning. *Academic Medicine, 77 (2):162-72.*

Maudsley, G. (2003). The limits of tutors' comfort zones with four integrated knowledge themes in a problem-based undergraduate medical curriculum (Interview study). *Medical Education, 37: 417 – 423.*

Maudsley, G., & Strivens, J. (2000). 'Science', 'critical thinking', and 'competence' for Tomorrow's Doctors. A review of terms and concepts. *Medical Education, 34(1): 53 – 60.*

May, W. (1990). *A case study of fourth-year medical students during a problem-based course in family medicine (Doctoral dissertation*, University of Southern California, 1990, Dissertation Abstracts International, 51: 07A.

McDermott, J., and Anderson, A., (1991). Retraining Faculty for the Problem based curriculum at the University of Hawaii, 1989-1991. *Academic medicine, 66:778-779.*

McGuire, C. H. (1985). Medical problem-solving. *Journal of Medical Education, 60: 587-595.*

McKernan, J. (1991). *Curriculum Action Research: A Handbook of Methods for and Resources for the Reflective Practitioner.* London, Kogan Page.

McLaughlin, C., & Kaluzen, A. D. (1994). *Continuous Quality improvement in healthcare: Theory, Implementation and Applications.* Gaithersburg, MD: Aspen.

McLean, M., Henson, Q., & Hiles, L. (2003). The possible contribution of student drawings to evaluation in a new problem-based learning medical programme: a pilot study. *Medical Education, 37: 895 – 906.*

Macpherson, R., Jones, A., Whitehouse, C. R., & O'Neil, P. A. (2001). Small group learning in the final year of a medical degree: A quantitative and qualitative study. *Medical Teacher, 23:494-9.*

Mennin, S., & Martinez-Burrola, N. (1985). *Cost of Problem-Based Learning.* In Kaufman, A. (Eds). Implementing Problem-Based Learning, lessons from successful innovations. New York: Springer.

Mennin, S. P., Friedman, M., Skipper, B., Kalishman, S., & Snyder, J. (1993). Performances on the NBME I, II, and III by medical students in the problem-based learning and conventional tracks at the University of New Mexico [see comments]. *Academic Medicine, 68: 616-624.*

Merriam, S. (1990). *Case Study Research in Education, A Qualitative Approach.* San Francisco: Jossey-Bass Publishers.

Merriam-Webster's Collegiate Dictionary (2007). *Map of Saudi Arabia.* Springfield, Mass: Merriam-Webster, Inc.

Messick, S. (1989). *Validity of Psychological Assessmetn: Validation of inferences from persons' responses and performances as scientific inquiry into score meaning.* Keynote address presented at the conference on Contemporary Psychological Assessment, Stockholm, Sweden.

Mezeiro, J. (1981). A critical theory of adult learning and education. *Adult Education, 32: 3-24.*

Miflin, B. (2004). Problem-based learning: The confusion continues. *Medical Education, 38: 921-926.*

Milaat, W., El-Gamal, F. (1994). Factors affecting the use and attitude towards medical resources and educational methods in Saudi medical school. *Annals of Saudi Medicine, 14(3): 209-214.*

Miller, G. E., (1961). *Teaching and Learning in Medical School.* Harvard University Press, Cambridge, Massachussets.

Miles, R. (1987). *Experiential Learning in the Classroom.* In P. Allan and M. Jolly (Eds). The Curriculum Nursing Education, Croom Helm. London.

Ministry of Education. (1986). *Development of education in the Kingdom of Saudi Arabia 1983-1986 AD: Educational Development.* Riyadh, Saudi Arabia, Ministry of Education Press.

Ministry of Education (2002). Merged the General Presidency for Girls Education into the Ministry of Education. *Al-Tuthig Al-Turboi Journal, Issue No (47), Saudi Arabia, Ministry of Education Press.*

Ministry of Planning. (2005). *Eight Development Plan 2005-2010.* Riyadh, Ministry of Planning Press.

Ministry of Planning. (1999). *Statistical Yearbook: Thirty Fifth Issue.* Riyadh, Saudi Arabia, Ministry of Planning Central Department of Statistics.

Mitchell, R., (1992). *The development of the cognitive behaviour survey to assess medical student learning.* Paper presented at the annual meeting of the American Education Research Assocation, San Francisco, Ca.

Mjoor, G., Schmidt, H., Snellen-Balendong, H., Moost, J., Stalenhoef-Halling, B., (1990). *Construction of problems for problem-based learning. In Nooman, Z., Schmidt, H., Ezzat, E., (eds).* Innovation in medical education: an evaluation of its present status. New York: Springer,114-122.

Moore, G., (1991). The effect of compulsory participation of medical students in problem based learning. *Medical Education, 25, 140-143.*

Morrison, J. M., & T. S. Murray (1994). An Experiment in problem-based learning. *Medical Education, 28: 139-145.*

Morales-Mann, E. T., & Kaitell, C. A., (2001). Problem-based learning in a new Canadian Curriculum. Issues and Innovations in Nursing Education. *Journal of Advanced Nursing, 33 (1): 13 – 19.*

Mowat, H., & Stewart, S. (1999). Using problem-based learning as part of general dental practice vocational training. *British Dental Journal, 187(2), 101 – 105.*

Mpofu, D. J., Lamphear, J., Stewart, T., Das, M., Ridding, P., & Dunn, E. (1998). Facility with English and Problem-based Learning group interaction: Findings from an Arabic setting. *Medical Education, 32:479-485.*

Mutabbakani, S. (1993). *Saudi Arabia Modern Economy, Traditional Society.* Saudi Arabian Cultural Mission.

Muller, S. (1984). Physicians for the twenty-first century, report of the project panel on the general professional education of the physician and college preparation for medicine. *Journal of Medical Education, 59: 2:1-3.*

Murphy, K., & Atkins, S. (1994). *Reflection with a practice-led curriculum.* In A. M., Planner, S. Burns and C. Bulman (eds), Reflective practice in Nursing: the growth of the professional practitioner, Blackwell, London.

Myler-Crook, C. (1974). *Behavioural Science for Medical Students.* Bulletin of the British Psychological Society, 27:403-406.

Neame, R. L. B. (1984). The preclinical course of study-help or hindrance? *Journal of Medical Education, 59:699-707.*

Neame, R. L. B., & Powis, P. A. (1981). Toward independent learning: curricular design for assisting students to learn how to learn. *Journal of Medical Education, 56:886-893.*

Network – Toward Unity for Health (Network – TUFH). Date accessed August 7, 2007.
Available: URL: http://www.the-networktufh.org.

Neufeld, V. R., & Barrows, H.S. (1974). The 'McMaster philosophy:' An approach to medical education. *Journal of Medical Education, 49: 1040-1050.*

Neufeld, V. R., Woodward, C. A., & MacLeod, S. M. (1989). The McMaster MD Programme: A case study of renewal in medical education. *Academic Medicine, 64:423-32.*

Newble, D. I., Clarke, R. M. (1986). The approaches to learning of students in a traditional and an innovative problem-based medical school. *Medical Education; 20:267-73.*

Newell, A. (1973). *Artificial intelligence and the concept of mind.* In Shank and Colby (eds). Computer Model of Language and Thought. Oxford: Freeman Publishing.

Newman, C. (1957). *The Evolution of Medical Education in the Nineteenth Century.* Oxford University Press, London.

Newman, M. (2006). *Fitness for purpose evaluation in Problem-based Learninng should consider the requirements for establishing descriptive causation.* Advances in Health Sciences Education, 11: 391-402.

Newman, M. The pilot group. (2003). *A Pilot Systematic Review and Meta-Analysis on the Effectiveness of Problem Based Learning.* On behalf of the Campbell Collaboration Systematic Review Group on the effectiveness of problem based learning. Newcastle: Learning and Teaching Support Network for medicine, dentistry and veterinary medicine. Date accessed, 27/2/07. Available; URL: http://www.medicine.heacadmy.ac.uk/docs/pbl_report.pdf

Nieuwenhuijzen, A. C., Kolle, M., & Scherpbler, A.J.J.A. (1997). *Problem-based learning at Maastricht – an assessment of cost and outcome.* Education for Health, 10 (2):179-187.

Nooruddin, Z.I., & Jaffery, M.J. (2004). A Problem-Based Learning-based structured genetic curriculum. *Medical Education, 38:1181 – 1202.*

Norman, G. R., Tugwell, P., Fightner, J. W., Muzzin, L. J., & Jacoby, L. L. (1985). Knowledge and clinical problem-solving. *Medical Education, 19:344-356.*

Norman, G. R. (1988). Problem-solving skills, solving problems and problem-based learning. [Review] [29 refs]. *Medical Education, 22: 279-286.*

Norman, G., & Schmidt, H. (1992). The psychological basis of problem-based learning: A review of the evidence. *Academic Medicine, 67(9): 59-71.*

Norman, G.R., & Schmidt, H.G. (2000). Effectiveness of problem-based learning curricula: theory, practice and paper darts. *Medical Education, 34: 721– 728.*

Nvivo inc. (2006). Qualitative Data Analysis Software Package. Melbourne, Australia: QSR International.

O'Neill, P. A., Willis, S. C., & Jones, A. (2002). A model of how students link problem-based learning with clinical experience through "elaboration". *Academic Medicine, 77: 552-561.*

O'Neill, P.A., Morris, J., & Baxter, C. (2000). Evaluation of an integrated curriculum using problem-based learning in a clinical environment: the Manchester experience. *Medical Education, 34: 222 – 230.*

Oppenheim, A. (1992). *Questionnaire Design, Interviewing and Attitude Measurement.* London, Pinter Publishers Ltd.

Pales, J., & Gual, A. (1992). Active and problem-based learning: two years' experience in physiology at the Medical School of the University of Barcelona. *Medical Education, 26: 466-472.*

Patel, V.L. & Daupinee, W.D. (1984). Return to basic sciences after clinical experience in undergraduate medical training. *Medical Education, 19: 54-60.*

Patel, V. L., Evans, D. A., & Kaufman, D. R. (1990). Reasoning strategies and the use of biomedical knowledge by medical students. *Medical Education, 24: 129-136.*

Patel, V. L. Groen, G. J., & Norman, G. R. (1991). Effects of conventional and problem-based medical curricula on problem solving. *Academic Medicine, 66: 380-389.*

Patel, V.L. & Groen, G.J. (1986). *Knowledge based solution strategies in medical reasoning.* Cogn Sci, 10:91 - 116.

Pitts, J. (2007). *Portfolios, personal development reflective practice. Understanding medical education series* . Association for Study of Medical Education (ASME). Edinburgh.

Post, G. J., & Drop, M. J. (1990). *Perceptions of the content of medical curriculum at the medical faculty in Maastricht: A comparison with traditional curricula in the Netherlands.* In Nooman, Shmidt, and Ezzat (eds). Innovation in Medical Education: An evaluation of its present status. New York. Springer Publishing Company, 114-123.

Powell, J. H. (1984). The reflective practitioner in nursing. *Journal of Advanced Nursing, 14:824-832.*

Prince, KJAH, van de Wiel MWJ, Scherpbier, AJJA, van der Vluten, CPM, Boshuizen, HPA. (2000). *A qualitative analysis of the transition from theory to practice in undergraduate training in a PBL medical school.* Advance Health Science Education Theory Practice, 5:105-16.

Prince, K., van Eijs, P., Boshuizen, H., van der Vleuten, C., & Scherpbier, A. (2005). General competencies of problem-based learning (PBL) and non-PBL graduates. *Medical Education, 39: 394 – 401.*

Refaat, A.H., Nooman, Z.M., (1989). *A model for planning a community based medical school curriculum.* Annals of community-orientated education, 2: 7-18.

Riccardi, V. M., & Schmickel, R. D. (1988). *Survey of medical schools' human genetics curricula.* Presented at the annual meeting of the American Society of Human Genetics (October 1985). Utah. Information and Education Committee Task Force, 2:60-81.

Rico, E., Galindo, J., & Marset, P. (1981). *Remembering Biochemistry: A Study of the Patterns of Loss of Biochemical Knowledge in Medical Students.* Biochemical Education, 9 (3):100-102.

Robson, C. (1996). *Real World Research, A Resource for Social Scientists and Practitioner Researchers.* Oxford, Blackwell.

Rogers, C. R. (1983). *Freedom to Learn for the Eighties.* Merrill, Columbus, Ohio.

Rolfe, I., Cameron, I., Lowe, M., & Aldrich, R. (1997). *Graduate perspective.* In Henry, R., Byrne, K., Engel, C. (Eds) Imperatives in Medical Education: The Newcastle Approach. The University of Newcastle (Australia), Faculty of Medicine and Health Sciences.

Roscoe, J. J. (1979). *Fundamental research statistics for behavior science.* New York: Holt Rinechart Winston, Inc.

Ryle, G. (1949). *The concept of mind.* Peregrine, Harmondsworth.

Salvatori, P. (2000). Implementing a problem-based learning curriculum in occupational therapy: A conceptual model. *Australian Occupational Therapy Journal, 47: 119 – 133.*

Santos-Gomez, L., Kalishman, S., Rezler, A., Skipper, B., & Mennin, S. P. (1990). Residency performance of graduates from a problem-based and a conventional curriculum. *Medical Education, 24: 366-375.*

Savin-Barden, M. (2000). *Problem-based learning in higher education: Untold stories.* Open University Press: Buckingham.

Saylor, C. R. (1990). *Reflection and Professional Education: Art, Science and Competency.* Nurse Educator, 15:8-11.

Schmidt, H. G., & Molen, H. T. (2001). Self-reported competency ratings of graduates of a problem-based medical curriculum. *Academic Medicine, 76: 466-468.*

Schmidt, H. G. (1998). Problem-based learning: does it prepare medical students to become better doctors? [editorial; comment]. *Med J Aust, 168: 429-430.*

Schmidt, H. G. (1993). Foundations of problem-based learning: some explanatory notes. *Medical Education, 27: 422-432.*

Schmidt, H. G., Dauphinee, D., & Patel, V. (1987). Comparing the effects of problem based and conventional curricula in an international sample. *Journal of Medical Education, 62:305-315.*

Schmidt, H. G., & DeVolder, M. L.(Eds.). (1984). *Tutorials in problem-based learning: New directions in training for the health professions.* Assen/Maastricht, Netherlands:VanGorcum.

Schmidt, H. G. (1983). Problem-based learning: rationale and description. *Medical Education, 17: 11-16.*

Schmidt, H. G., Norman, G. R., & Bouhuijs, P. A. (1990). A cognitive perspective on medical expertise. *Academic Medicine, 95:611-621.*

Schon, D. (1983). *The reflective practitioner: How professionals think in action.* Kogan Page, London.

Schwartz, A. H., Swartzburg, M., Lieb, J., & Slaby, A. E. (1978). Medical School and the Process of Disillusionment. *Medical Education, 12:182-185.*

Schwartz, B.J., & Snow, L. H. (1974). On getting kicked out of medical school. *American Journal of Psychotherapy, 28:574.*

Schwartz, P. L., Fiddes, T. M., & Dempster, A. G. (1991). The case-based learning day: introducing problem-based learning into a traditional medical curriculum. *Medical Teacher, 9: 275-280.*

Shawky, S., & Soliman, N. K. (1990). Going beyond the curriculum to promote medical education and practice in Saudi Arabia. *Saudi Medical Journal, 22 (6):477-48.*

Silver, M., & Wilkerson, L. A. (1991). Effects of tutors with subject expertise on the problem-based tutorial process. *Academic Medicine, 66: 298-300.*

Simpson, M. A. (1972). *Medical Education: A Critical Approach.* Butterworth, London, United Kingdom.

Slavin, R. (1984). *Research Methods in Education: A Practical Guide*. Englewood Cliffs, New Jersey, Prentice Hall Inc.

Small, P.A. Jr (1988). Consequences for medical education of problem-solving in science. *Medical Education, 63: 848-853.*

Smith, H. C. (2002). A course director's perspectives on problem-based learning curricula in biochemistry. *Academic Medicine, 77: 1189-1198.*

Smith, A. N., & Scott, J. A. (1985). Genetic application for health professionals: An outreach continuing education program. *American Journal of Human Genetics, 43: 559-562.*

Smits, P. B. A., Verbeek, J. H. A. M., & de Buisonje, C. D. (2002). Problem-Based Learning in Continuing Medical Education: A review of controlled evaluation studies. *BMJ: 324:153-6.*

Southern Illinois University, "The Problem-Based Learning Initiative". Date accessed, April 12, 2006.
Available: URL: http://www.pbli.org/care.htm.

Spencer, J.A., & Jordan, R.K. (1999). Learner centred approaches in medical education. *British Medical Journal, 1280 – 1283.*

SPSS Inc. (2005). *Statistical_Package for the social sciences*. Version 14.0. 444 North Michigan Ave., Chicago, Ill.

Srinivasan, M., Wikes, M., Stevenson, F., Nguyen, T., & Slavin, S. (2007). Comparing problem-based learning with case-based learning: Effects of a major curricular shift at two institutions. *Academic Medicine, 82(1).*

Steinert, Y. (2004). Student perceptions of effective small group teaching. *Medical Education, 38:286-93.*

Swinford, A. E., & McKeag, D. B. (1990). Incorporation of genetics into a problem-based medical school curriculum. *American Journal of Human Genetics, 47: 753-758.*

Tallis, R. (2005). *Hippocratic Oaths: Medicine and its discontents.* London: Atlantic Books.

Tan, O. S. (2003). *Problem-based learning innovation: using problems for power learning in the 21st century.* Singapore Thomson Learning.

Tan, O. S. (2005). *Problem-based learning: the future frontiers,* p. 17-32. In Tan, K., Lee, M., Mok, J. & Ravindran, R. (Eds). *Problem-based learning: new directions and approaches.* Singapore Learning Action, TCPBL.

Tan, O. S. (2007). *Problem-based learning pedagogies: psychological processes and enhancement of intelligences.* Educational Research for policy and practice.

Tashakkori, A., & Teddlie (Eds). (2003). *Handbook of mixed methodology in social and behavioural research.* Thousand Oaks, CA: Sage.

Ten Cate, O., Snell, L., Mann, K., & Vermunt, J. (2004). Orienting teaching toward the learning process. *Academic Medicine, 79 (3):219-28.*

Thomas, R.E., (1997). Problem-based learning: measureable outcomes. *Medical Education, 31:320-329.*

Tiwary, A., Lai, P., So, M., Yue, K. (2006). Comparison of the effects of Problem-Based Learning and lecturing on the development of students' critical thinking. *Medical Education, 40:547-54.*

Tomlinson, A. (1985). *The use of experiential methods in teaching interpersonal skills to nurses.* In C. M. Kagan (Ed) Interpersonal skills in nursing: research and applications, Croom Helm, London.

Torbeck, L., Joyce, J., & Flannery, M. (2004). Integrating experiential learning in complementary and alternative medicine. *Medical Education, 38:1181-1202.*

Tosteson, D. C., Adelstein, S. J., & Carver, S. T. (1994). *New pathways to medical education: learning to learn at Harvard medical school.* Cambridge, Mass: Harvard University Press.

Towle, A. (1991). *Critical thinking. The future of undergraduate medical education.* London: King's Fund Centre.

Tuckman, B. W. (1999). *Conducting educational research (5th ed).* Belmont, CA: Wadsworth Group / Thompson Learning.

Tylor, C. (1984a). *Hegel, history and politics*, in M. Sandel (ed) Liberalism and its critic. Oxford, Blackwell.

Tymms, P. & Fitz-Gibbon, C. (2002). *Theories, hypothesis, hunches and ignorance.* Building Research Capacity, 2:10-11.

Tymms, P. (2007). *Personal communication with the research during thesis supervising.* 10th June (Ed) School of Education, University of Durham.

Usher, R. S., & Bryant, I. (1987). *Re-examining the theory-practice relationshi.* Studies in Higher Education, 70:216-223.

Van den Hurk, M. M., Dolmans, DHJM., Wolfhagen, IHAP., & van der Vleuten, CPM. (2001). *Testing a causal model for learning in a problem-based curriculum.* Adv Health Sci Educ, 6:141-9.

Van den Hurk, M. M., Dolmans, DHJM., Wolfhagen, IHAP., & van der Vleuten, CPM. (1999). Impact of individual study on tutorial group discussion. *Teach Learn Med, 11 (4):196-201.*

Verhoeven, B.H., Verwijnen, G.M., Scherpbier, A.J., Holdrinet, R.S., Oeseburg, B., Bulte, J.A., et al. (1998). An analysis of progress of PBL and non-PBL students. *Medical Teacher, 20(4): 1-7.*

Vernon, D., & Blake, R. (1993). Does problem-based learning work? A meta-analysis of evaluative research. *Academic Medicine, 68(7):550-563.*

Verwijnen, M., van der Vleuten, C., & Imbos, T. (1990). *A comparison of innovative medical schools with traditional schools: An analysis in the cognitive domain.* In Nooman, Schmidt & Ezaat (Eds.), Innovation in medical education: An evaluation of its present status. New York: Springer Publishing.

Visschers-Pleijers, A.J.S.F., Dolmans, D.H.J.M., Wolfhagen, H.A.P., & van der Vleuten, C.P.M. (2004). Exploration of a method to analyze group interactions in problem-based learning. *Medical Teacher, 26 (5):471-8.*

Wallen, N., & Fraenkel, J. R. (2001). *Educational Research (2nd ed).* New Jersey: Lawrence Erlbaum Associates, Inc.

Walton H., ed. (1994). Proceedings of the 1993 World Summit on Medical Education of the World Federation for Medical Education. *Medical Education, 28 (1):1-171.*

Walton, H., & Matthews, M. (1989). Essentials of problem-based learning. *Medical Education, 23:542-558.*

Way, D.P., Hudson, A., & Biagi, B. (2000). Comparison of three parallel, basic science pathways in the same medical college. *Academic Medicine, 75(10): 188 – 120.*

Weatherall, D. J. (1985). *The new genetics and clinical practice* (2nd ed.). New York: Oxford Press.

Wellington, J. (1996). *Methods and Issues in Educational Research (1st ed),* United Kingdom, University of Sheffield, Division of Education.

West, D. A., & West, M. M. (1987). Problem-based learning of psychopathology in a traditional curriculum using multiple conceptual models. *Medical Education, 21: 151-156.*

Whitman, N., Ramsey, R., & Goodenough, G. K. (1987). *A problem-based, student-centered approach to teaching geriatrics in the classroom.* Gerontology Geriatric Education, 8: 101-112.

Wilkerson, L., Hafler, J. & Liu, P. (1991). A case study of student directed discussion in four problem based tutorial groups. *Academic medicine, 66:579-581.*

Williams, M. (2003). *Making sense of social research.* Sage Publishers Ltd.

Wingard, J. R., & Williamson, J. W. (1973). Grades as predictors of physicians' career performance: an evaluative literature review. *Journal of Medical Education, 48:311-322.*

Winston, I., & Szarek, J. L. (2005). Problem-Based Learning using a human patient simulator. *Medical Education, 39:505-533.*

Wolf, F. (1993). Problem-Based Learning and meta-analysis: Can we see the forest through the trees? *Academic Medicine, 68(7): 542-544.*

Woodward, C. A., Ferrier, B. M., Cohen, M., & Goldsmith, C. A. (1990). A comparison of the practice patterns of general practitioners and family physician graduating from McMaster and other Ontario medical schools. *Teaching Learning Medicine, 71:1079-89.*

Wright, S. (1958). *Genetics, the gene and the hierarchy of biological sciences.* Proceedings of the Tenth International Congress on Genetics, 1:474-489 .

Yee, Y. H., Radha Krishnan, A. & Ponnudurai, G. (2006). Improving PBLs in the international medical university: defining the 'good' PBL facilitator. *Medical Teacher, 28(6):558-560.*

Zeitz, H. J., & Paul, H. (1993). Facilitator expertise and problem-based learning in PBL and traditional curricula. *Academic Medicine, 68: 203-204.*

APPENDICES

- **Appendix A**
  Instruments

- **Appendix B**
  Curriculum Materials

- **Appendix C**
  Tutor Training Development Materials

- **Appendix D**
  Student Development Materials

- **Appendix E**
  Pre-test and GLM Data Analysis

- **Appendix F**
  Durham University Ethics Committee permission letter

APPENDIX A

INSTRUMENTS

- Cognitive Behaviour Survey (CBS)
- Demographic Questionnaire (DQ)
- Attitude Survey (AS)
- Course Evaluation Form (CEF)
- Tutor Evaluation Form (TEF)
- Genetics Unit Examination (GUE)

COGNITIVE BEHAVIOUR SURVEY (CBS)

Date: ____________________________ University: __________________________

ID: ____________________________ Group: _______ (#) Pre-Clinical ☐ Clinical ☐

Method of Teaching: ☐ PBL ☐ LBC Sex: ☐ Female ☐ Male

- The purpose of this survey is to obtain information about how you learned about human genetics.
- The responses to this survey are confidential and will be used for research purposes only.
- Throughout the survey, the terms **memorization** and **visualization** are used to describe learning behaviour.
- **Memorization** refers to rote learning.
- **Visualization** is described as a learning process characterized by mental construction of a picture to represent the information.

How important has each of the behaviours, listed in items 1 to 10, been in your learning of human genetics?

Use "1" to indicate *not at all important* and "7" to indicate *of the highest importance*

	→Increasing Importance→						
1. Memorization of the key features of the process.	1	2	3	4	5	6	7
2. Establishment of a conceptual model for the general understanding of how the mechanism works.	1	2	3	4	5	6	7
3. Establishment of an overview of the process (i.e. formulating a general impression).	1	2	3	4	5	6	7
4. Drawing a visual representation of the process (e.g. a diagram).	1	2	3	4	5	6	7
5. Using analogies or metaphors.	1	2	3	4	5	6	7
6. Constructing a flow chart.	1	2	3	4	5	6	7
7. Initially learning the details of a process, then constructing a general picture of the process.	1	2	3	4	5	6	7
8. Creating a mnemonic device such as an acronym.	1	2	3	4	5	6	7
9. Discussing a scientific process or concept with other students.	1	2	3	4	5	6	7
10. Reading other texts on the same material.	1	2	3	4	5	6	7

Cognitive Behaviour Survey (CBS)...........continued

How important has each of the following abilities, listed in items 11 to 16, been to your success in the human genetics units?

Use "1" to indicate *little importance* and "7" to indicate *major importance.*

	→Increasing Importance→						
11. The ability to memorize large amounts of material in a short period of time.	1	2	3	4	5	6	7
12. The ability to read quickly with accurate comprehension.	1	2	3	4	5	6	7
13. The ability to remember a large number of details.	1	2	3	4	5	6	7
14. The ability to construct effective classification systems for large amounts of details.	1	2	3	4	5	6	7
15. The ability to formulate conceptual models which explain the cause-effect relationships of different processes.	1	2	3	4	5	6	7
16. The ability to construct visual images (mental pictures) to represent information.	1	2	3	4	5	6	7

In terms of the way you read a human genetics textbook or papers for Human Genetics units, how representative are the statements 17 to 24?

Use "1" to indicate *not representative* and "7" to indicate *very representative.*

	→Increasing Representation→						
17. As I read, I underlined or highlighted.	1	2	3	4	5	6	7
18. As I read, I made notes in the margins.	1	2	3	4	5	6	7
19. As I read, I made an outline of the important material.	1	2	3	4	5	6	7
20. As I read descriptions of physiological mechanisms, I tried to construct a mental image of the process.	1	2	3	4	5	6	7
21. As I read, I tried to memorize the key points.	1	2	3	4	5	6	7
22. As I read, I related the material to what I had previously learned.	1	2	3	4	5	6	7
23. As I read, I identified information to be memorized later.	1	2	3	4	5	6	7
24. As I read, I analysed the relevant diagrams or pictures.	1	2	3	4	5	6	7

Answer the following questions *in terms of percentages.*

25. At the end of the Human Genetics units, estimate the average percent of your knowledge that was the result of rote memorization. ______%

26. What percentage of what you studied for the exam do you think you will remember one year after completing this course? ______%

27. What percentage of the Human Genetics you learned for the exam do you think you'll remember three months later? ______%

28. What percentage of your study time was devoted to memorization of the Human Genetics units? ______%

29. What percent of your study time do you estimate was wasteful or ineffective for the Human Genetics unit? ______%

Why did you memorize for the Human Genetics units?

Use "1" to indicate *minor* reason and "7" to indicate *major* reason.

	→Increasing Importance of Reason→						
30. It was an effective way to learn.	1	2	3	4	5	6	7
31. It was a fast way to learn.	1	2	3	4	5	6	7
32. There was too much to learn by any other method.	1	2	3	4	5	6	7
33. It was easy.	1	2	3	4	5	6	7
34. It was necessary to establish a basic foundation of knowledge.	1	2	3	4	5	6	7

For the Human Genetics units in this course:

Use "1" to indicate *seldom* and "7" to indicate *frequently.*

	→Increasing Frequency→						
35. How often did you study with other students prior to an exam?	1	2	3	4	5	6	7
36. Have you studied with another student(s) on a regular basis?	1	2	3	4	5	6	7
37. Excluding your preparation for exams, did you ever discuss with other students material which was conceptually confusing?	1	2	3	4	5	6	7

Answer these following questions in terms of percentages:

On average, what percentage of your knowledge on human genetics came from the following sources? (Your total should add up to 100%).

38. Lectures ______%

39. Tutorials ______%

40. Faculty outside of class ______%

41. Other students outside of class ______%

42. Textbooks ______%

43. Articles ______%

44. Labs ______%

45. Other (please specify) ______________________________ ______%

Total 100%

To what extent do the following words and phrases describe your learning experience for the Human Genetics units?

Use "1" to indicate *not at all descriptive* and "7" to indicate *very descriptive*

	→Increasingly Descriptive→						
46. Meaningful	1	2	3	4	5	6	7
47. Enjoyable	1	2	3	4	5	6	7
48. Stressful	1	2	3	4	5	6	7
49. Stimulating	1	2	3	4	5	6	7
50. Uneventful	1	2	3	4	5	6	7
51. Sense of discovery	1	2	3	4	5	6	7
52. Motivating	1	2	3	4	5	6	7
53. Leads to new question	1	2	3	4	5	6	7

To what extent do the following words and phrases describe your view of your genetics knowledge?

Use "1" to indicate *not at all descriptive* and "7" to indicate *very descriptive.*

	→Increasingly Descriptive→						
54. Fallible	1	2	3	4	5	6	7
55. Descriptive	1	2	3	4	5	6	7
56. Contradictory	1	2	3	4	5	6	7
57. Stable	1	2	3	4	5	6	7
58. Definitive	1	2	3	4	5	6	7
59. Precise	1	2	3	4	5	6	7

DEMOGRAPHIC QUESTIONNAIRE (DQ)

Date: ______________________________ University: ___________________________

ID: ______________________________ Group: ________ Pre-Clinical ☐ Clinical ☐
(#)

Method of Teaching: ☐ PBL ☐ LBC Sex: ☐ Female ☐ Male

- This information, which will not be a part of your student record, will be kept confidential and used for research purposes only.

---

1. Age: _____

2. Major topic of interest regarding human genetics: HBD ☐ HCD ☐ HMD ☐

3. Have you ever participated in classes which included the use of case studies? Yes ____ No ____

4. If your answer to item 4 was "YES", did you like learning from case studies? Yes ____ No_____

5. Have you ever been exposed to an educational strategy identified as "problem-based learning" before? Yes _____ No _____

   If yes, when and in which class(es)? ____

6. Have you ever taken a course that included a significant amount of information about:

   Molecular bases of genetic diseases Yes _____ No _____

   Chromosomal aberrations Yes _____ No _____

   Other genetic diseases Yes _____ No _____

7. Do you have experience in caring for persons with sickle-cell anaemia ? Yes ___ No_____

8. Do you have experience in caring for persons with Down's syndrome? Yes _____ No _____

9. If you answered "YES" to items 8 and/or 9, please describe your role and responsibility in this care ____

____

____

____

____

____

[Thank you for your cooperation]

ATTITUDE SURVEY (AS)

Date: ____________________ University: ____________________

ID: ____________________ Group: ________ Pre-Clinical ☐ Clinical ☐
(#)

Method of Teaching: ☐ PBL ☐ LBC Sex: ☐ Female ☐ Male

- Please circle the number which characterizes your feelings about each of the following statements.

For me, learning about medicine is:

Use "1" to indicate that you *disagree* and "7" to indicate that you *agree*

	→Increasing Agreement→						
frustrating	1	2	3	4	5	6	7
challenging	1	2	3	4	5	6	7
exciting	1	2	3	4	5	6	7
depressing	1	2	3	4	5	6	7
boring	1	2	3	4	5	6	7

When I qualify, working with Genetics patients will be:

Use "1" to indicate that you *disagree* and "7" to indicate that you *agree*

	→Increasing Agreement→						
frustrating	1	2	3	4	5	6	7
challenging	1	2	3	4	5	6	7
exciting	1	2	3	4	5	6	7
depressing	1	2	3	4	5	6	7
boring	1	2	3	4	5	6	7

For me, a career focusing on medicine would be:

Use "1" to indicate that you *disagree* and "7" to indicate that you *agree*

	→Increasing Agreement→						
likely	1	2	3	4	5	6	7
rewarding	1	2	3	4	5	6	7

The problems associated with patients are:

Use "1" to indicate that you *disagree* and "7" to indicate that you *agree*

	→Increasing Agreement→						
frightening	1	2	3	4	5	6	7
solvable	1	2	3	4	5	6	7
manageable	1	2	3	4	5	6	7

[Thank you for your cooperation]

COURSE EVALUATION FORM (CEF)

Date: ______________________ University: ______________________

ID: ______________________ Group: _______ (#) Pre-Clinical ☐ Clinical ☐

Method of Teaching: ☐ PBL ☐ LBC Sex: ☐ Female ☐ Male

- Please answer the questions yourself, based on your own opinions.

I. <u>The Response Regarding the HGU Evaluation:</u>

1. What method did you use to study Human Genetics Units (HGU)? PBL ☐ or LBC ☐
2. What percentage of the entire course should be using this method? _______ %
3. Please indicate the main factors you considered in making your response for the above

____ The enjoyment that I had using this method.

____ The importance of this method to my professional practice.

____ The volume of information I learned.

____ The interaction with my peers.

____ The independence of learning.

____ Other ______________________________

4. During the previous class sessions, I learned: (Please tick *one*)

_____ A lot more than I expected

_____ Somewhat more than I expected

_____ About as much as I expected

_____ Somewhat less than I expected

_____ Much less than I expected

5. The format used in the previous classes is one that I would: (<u>Please tick one</u>)

_____ Like to experience again

_____ Like to experience again if these minor changes were made: (<u>List minor changes</u>)

_____ Like to experience again if these major changes were made: (<u>List major changes</u>)

_____ Prefer not to experience again because: (<u>List reasons</u>)

II. <u>The Response Regarding The Amount of Work:</u>

6. Compared to the work I have done for this class so far, <u>the amount of work involved</u> in the previous class sessions was:

    _____ More than I am used to and intolerable

    _____ More than I am used to but tolerable

    _____ About the same as I am used to

    _____ Not as much as I am used to

7. Approximately <u>how much time</u> did you work outside of class to review/study materials for the past three class sessions? __________ (min/hour/days)

III. <u>Response Regarding The Tutor and Small-Group Process</u>

Circle the number which best reflects your level of agreement with the following statements.

Use "1" to indicate *hardly ever* and "7" to indicate *almost always*

	→Increasing Frequency→						
8. The leader allowed students to initiate and continue discussion	1	2	3	4	5	6	7
9. Periods of silence were tolerated by the leader	1	2	3	4	5	6	7
10. We interrupted each other during the sessions	1	2	3	4	5	6	7
11. Most of the questions were asked and answered by the students	1	2	3	4	5	6	7
12. Students selected most of the topics for discussion	1	2	3	4	5	6	7
13. Most of the exchanges were between students, not between the leader and the students	1	2	3	4	5	6	7
14. We were encouraged to listen fully to each other	1	2	3	4	5	6	7
15. The leader provided limited amounts of information	1	2	3	4	5	6	7
16. Students were allowed to discuss their ideas without the leader's intervention	1	2	3	4	5	6	7
17. I enjoyed working in my group	1	2	3	4	5	6	7

18. During this small-group experience, were you aware of the activities of at least one of the other small groups?

    __________ No __________ Yes (If yes, explain)

    ____

    ____

    ____

19. What are your perceptions of the use of PBL or LBC methods in this study?

[Thank you for your cooperation]

TUTOR EVALUATION FORM (TEF)

Date: ______________________ University: ______________________

ID: ______________________ Group: ______________________
(#)

- Please complete the following questions at the end of the each class session.

Use "1" to indicate *hardly ever* and "7" to indicate *almost always.*

	→Increasing Frequency→						
1. Students were allowed to initiate and continue discussion.	1	2	3	4	5	6	7
2. Periods of silence were tolerated.	1	2	3	4	5	6	7
3. The students and I interrupted each other during the sessions.	1	2	3	4	5	6	7
4. Most of the questions were asked and answered by the students.	1	2	3	4	5	6	7
5. Students selected most of the topics for discussion.	1	2	3	4	5	6	7
6. Most of the exchanges were between the students, not between the students and myself.	1	2	3	4	5	6	7
7. Students were encouraged to listen fully to each other.	1	2	3	4	5	6	7
8. I provided limited amounts of information during the class.	1	2	3	4	5	6	7
9. Students were allowed to discuss their ideas without my intervention.	1	2	3	4	5	6	7
10. I used infrequent questions to guide the group process or to probe for understanding.	1	2	3	4	5	6	7
11. Any questions I asked or statements I made were built on students' preceding comments.	1	2	3	4	5	6	7
12. The difficulty level was appropriate for the tutorial.	1	2	3	4	5	6	7
13. Students were enthusiastic and motivated to study this method.	1	2	3	4	5	6	7
14. The data sheet was adequate.	1	2	3	4	5	6	7

Categorize each factor according to the three choices:
Record the response by placing an "x" in the appropriate column; comments are welcome.

Factor	No Problem	Somewhat Problematic	Definite Problem	Comments
15. Rapport with students	_____	_____	_____	
16. Effectiveness as T/I	_____	_____	_____	
17. PBL process	_____	_____	_____	
18. Session length	_____	_____	_____	
19. Number of sessions	_____	_____	_____	
20. Topic order	_____	_____	_____	
21. Problem content	_____	_____	_____	
22. PBL data sheets	_____	_____	_____	
23. Instruction sheets	_____	_____	_____	
24. Student resources	_____	_____	_____	
25. Learning issues/HBD	_____	_____	_____	
26. Learning issues/HCD	_____	_____	_____	
27. Facilities	_____	_____	_____	
28. Group size	_____	_____	_____	

29. Would you consider being a PBL tutor/LBC instructor again? Yes ______ No ______
    If you wish, please explain your answer

30. What are your comments about the teaching method you were involved in?

[Thank you for your cooperation]

GENETICS UNIT EXAMINATION (GUE)

- The HGU Examination for preclinical students will consist of two parts (a total of 100 points):
- **Part I,** to be prepared by the Genetic Instructor at King Faisal University, will be worth 60 points . This part of the examination will include multiple choice, True/False questions and matching test items.
- **Part II,** to be prepared by the Researcher, will be worth 40 points. It will consist of 4 essay-type analytical questions that will cover both HBD and HCD, 20 points each.

- *The answers should be in the examination paper.*

Part I
Total points: ....

Part II
Total points: ....

Total: ________________

(For security reasons, the detail of the examination is not included here)

APPENDIX B

CURRICULUM MATERIALS

- Human Biochemical Disorder (HBD) Problem for PBL Students
    - The Human Biochemical Disorder (HBD) Problem

- Human Biochemical Disorder (HBD) Problem for LBC Students
    - HGU Questions for LBC Students
    - HBD – Objectives
    - Potential Learning Issues

- Human Chromosomal Disorder (HCD) Problem

- Human Chromosomal Disorder (HCD) for LBC Students
    - HGU Questions for LBC Students
    - HCD – Objectives
    - Potential Learning Issues

- Human Multifactorial Disorder (HMD)
    - HMD – Objectives
    - Potential Learning Issues

HUMAN BIOCHEMICAL DISORDER (HBD) PROBLEM FOR PBL STUDENTS

Problem Brief (PB)

The aim of this trigger is to understand the concepts of biochemical genetic disorders through a 14-month-old female brought to the paediatrics clinic who had been coughing, irritable and feverish for two days.

List the biochemical learning issues you plan to study in these three sessions.

Instructions:

- This sheet will be collected by tutor assigned.
- Do not write your name or ID number on this page.

The Human Biochemical Disorder (HBD) Problem

Part I

The Case History:

Johra is a 14-month-old infant female. She was brought to the paediatrics clinic by her father, Saad. She has been coughing, irritable and feverish for two days. She has been walking for about five weeks, but now seems reluctant to put weight on her left leg.

She was born at term and weighed 2.90 kg. She has no previous illness. She shows normal growth and development.

<u>Part I</u> (continued)

<u>The Family History</u>

Johra has three brothers and one sister. The oldest, Mohammed is 7 years old and has been diagnosed as a sickle-cell anaemic patient. Iman is a 5-year-old female and Ola is a 3 ½-year-old female. Both are in good health with no previous admissions.

Her father, Saad is 34 years old. He is a businessman who is quite healthy. Saad is married to Hind (the mother). She is 29 years old and is a teacher. She has no previous illnesses.

Johra's parents were married eight years ago. They are first cousins.

- You may proceed to the clinical examination data.

Part II

Clinical Examination Data:

The paediatrician immediately decided to admit her, and carry out a clinical examination.

The vital signs:

	Johra	Normal Range
Temperature, °C	38.5	36.5-37.5
Pulse Rate, beats/min	135	80-120
Blood Pressure, mm(Hg)	110/80	80-110/50-80
Respiration/min	30	20-30

Also,

Weight, kg	10	(≅ 50th per centile)
Height, cm	75	(≅ 50th per centile)

The physical examination

Johra appeared clinically anaemic. She was pale and in a lot of discomfort.

Cardiovascular system

Heart ejection systolic murmur grade 2/6 at left sternal border.

Respiratory system

Mildly tachypneic.
Decreased breath sounds over the left lower chest posteriorly.

Abdomen

Spleen and liver are palpable 2cm below the costal margin.

Neurological examination

Cranial nerves normal. The left leg shows no signs of knee or hip joint limitation, but a point of tenderness is elicited above and lateral to the knee joint, over the distal portion of the femur. The right leg is normal.

- You may proceed to the laboratory test data.

Part III

Laboratory Data:

Because of the family history of sickle-cell anaemia the paediatrician decided to order the following clinical and laboratory tests.

Haematological values:

	Johra	Normal Range
Haemoglobin (Hb) count, gr/l	105	115-165
Haemotocrit (PCV), %	29	36-47
Reticulocytes, %	8.0	0.5-2.5
Erythrocytes (RBC), $10^{12/l}$	4.0	3.8-5.8
Mean Cell Volume (MCV), Pg	81.0	77-95
Mean Cell Haemoglobin (MCH), Pg	30	27-32
Mean Cell Haemoglobin Concentration (MCHC), g/d	30	32-36
White blood cell (WBC) count, $10^{9/l}$	19.8	4.0-11.0
Neutrophils, $10^{9/l}$	11.8	2.0-7.5
Lymphocytes, $10^{9/l}$	6.7	1.5-4.5
Monocytes, $10^{9/l}$	0.6	0.2-0.8
Eosinophils, $10^{9/l}$	0.2	0.04-0.4
Basophils, $10^{9/l}$	0.5	0-0.1
Platelet count, $10^{9/l}$	380	140-400

Chemical pathology test values:

Urea, mmol/l	5.2	3.0-6.5
Albumin, gr/l	42	32-50
Total protein, gr/l	61	63-80
Total bilrubin, mmol/l	36	<17

Sickling test:

The red cells sickle deoxygenated with 2% sodium metabisulfite.

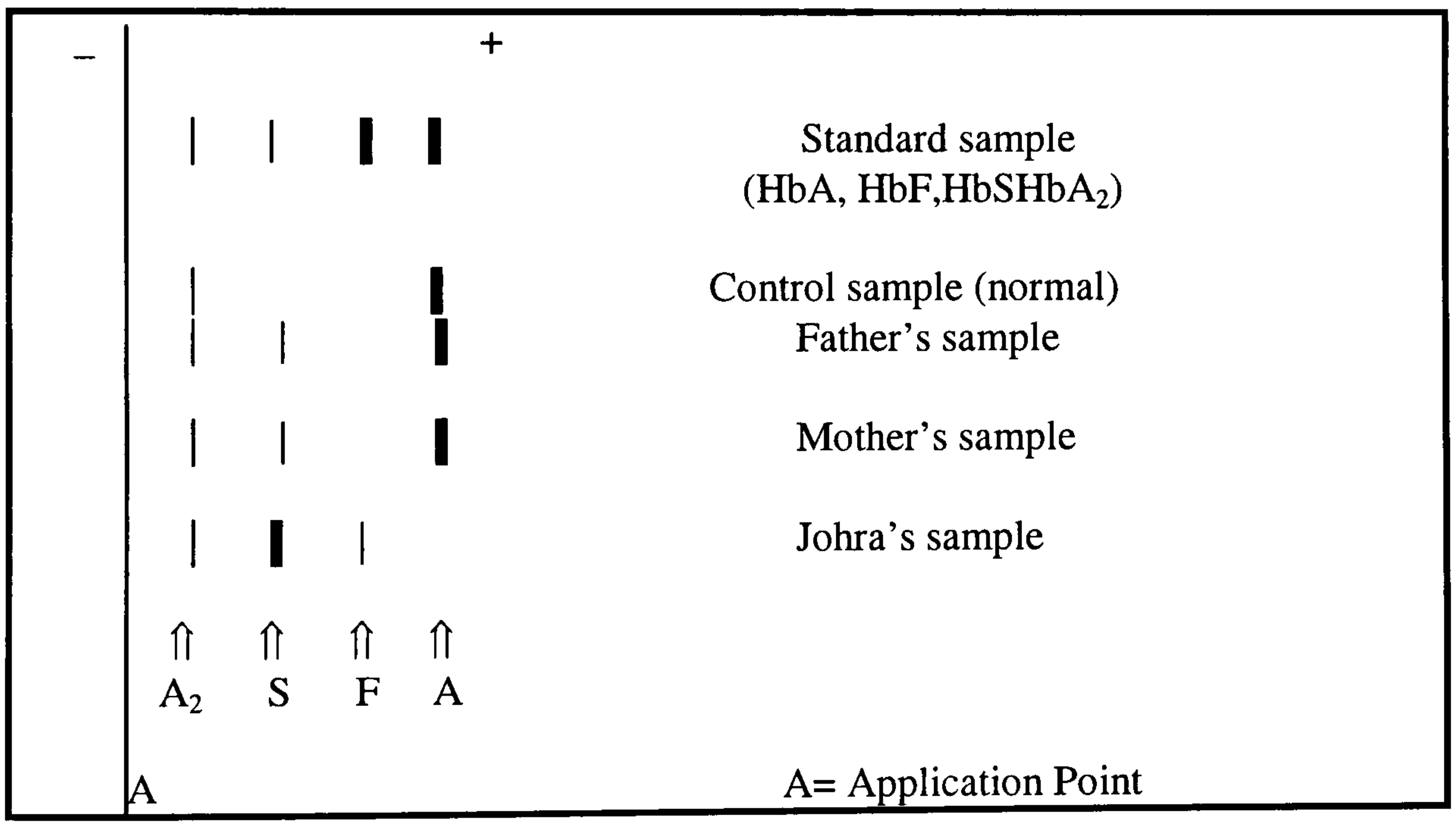
Haemoglobin solubility:

Homolysate became cloudy upon deoxygenation.

The peripheral blood smear:

Sickle blood cells. Normal blood cells.

The haemoglobin electrophoresis (cellulose acetate, PH 8.6):



X-Rays:

Chest: mild left lower lobe infiltrate.
Left leg: radiograph appears normal.

Part III

The Family Laboratory Data:

The paediatrician decided to order a family investigation concentrating especially on the parents.

Haematological values:

	Father	Normal Range
Haemoglobin (Hb) Count, gr/l	140.2	130-180
Haematocrit (PCV), %	0.45	0.40-0.52
Reticulocytes, %	1.5	0.5-2.5
Erythrocytes, (RBC), $10^{12/l}$	6.0	4.5-6.5
Mean cell volume (MCV), fl	83.1	77-95
Mean cell Haemoglobin (MCH), pg	29.2	27-32
Mean cell Haemoglobin concentration (MCHC), g/dl	33.4	32-36
White blood cells (WBC) count, $10^{9/l}$	8.9	4.0-11.0
WBC differential count, $10^{9/l}$	(normal distribution)	
Platelets, $10^{9/l}$	270	140-400

Peripheral blood smear:

Red cells sickle on deoxygenation.

Sickling test:

The red cells sickle deoxygenated with 2% sodium metabisulfite.

Haemoglobin solubility:

Homolysate becomes cloudy upon deoxygenation.

Part III (continued)

Haematological values:

	Mother	Normal Range
Haemoglobin (Hb) count, gr/l	122	115-165
Haematocrit (PCV), %	37.5	36-47
Reticulocytes	1.7	0.5-2.5
Erythrocytes (RBC), $10^{12/l}$	4.3	38-5.8
Mean cell volume (MCV), fl	83	77-95
Mean cell Haemoglobin (MCH), pg	31.3	27-32
Mean cell Haemoglobin concentration, g/dl	34.7	32-36
White blood cells (WBC) count, $10^{9/l}$	9.2	4.0-11.0
WBC differential count, $10^{9/l}$	(normal distribution)	
Platelets, $10^{9/l}$	240	140-400

Peripheral blood smear:

A few target cells; occasional sickled cells

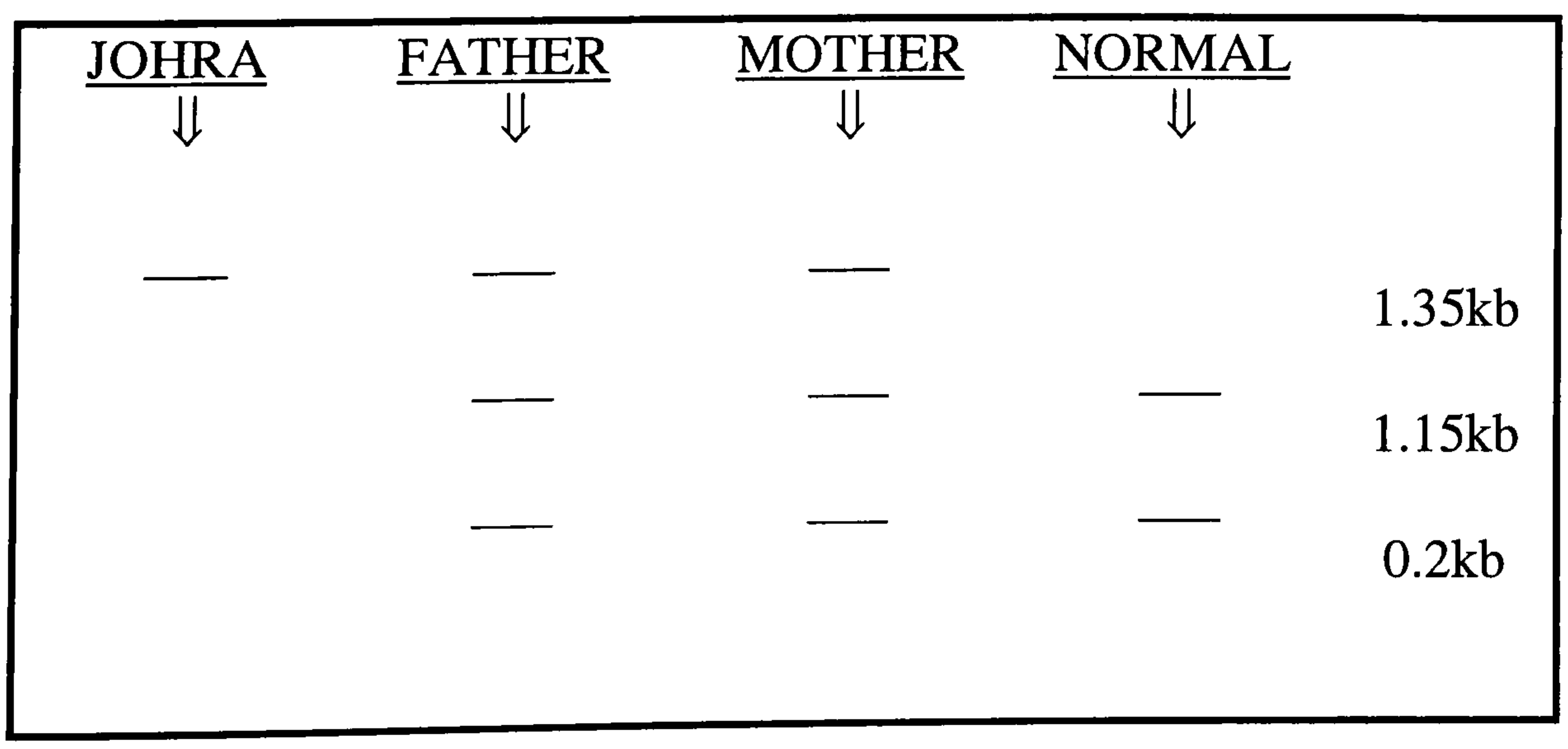
Sickling test:

The red cells sickle deoxygenated with 2% sodium metabisulfite.

Family southern blot data:

Procedure:

Electrophoresis of *MST II* fragments of DNA, followed by detection with a probe complementary to the B globin gene.



Part IV

Clinical Application:

Johra was given O_2 by mask for a while then left to rest in bed. She was also placed on intravenous fluid and intravenous Cefuroxime (2nd generation of Cephalosporin) after blood sample was taken.

After 48 hours in the hospital, she was still unable to put weight on her left leg and her fever was still high.

The patient showed no improvement; because of this she was taken to theatre where surgical drainage of the distal femur was done and this revealed pus which was consistent with osteomyelitis of the distal femur. There was no bacterial growth shown in the culture (microbiology test).

By the time of surgery, she had been on 3 antibiotics for 72 hours. Following the removal of the infection she became stable and remained so.

Johra was given 3 antibiotics I.V. including (Vancomycin), followed by oral Keflaxene (1st generation of cephalosporin) to be taken over a three-week period.

She made a complete recovery.

[Thank you for your cooperation]

HUMAN BIOCHEMICAL DISORDER (HBD) PROBLEM FOR LBC STUDENTS

William is an 18-month-old male Caucasian infant. He was diagnosed as a cystic fibrosis (CF) case, and because of this referred to have more investigations to confirm this diagnosis and have further evaluation.

He was born at full term with a normal delivery, his weight 2.85kg. He had been chesty since the age of 7 months and had been treated for pneumonia on two occasions. Over the past 6 months, his condition has worsened, and the coughing has increased. He has now started to become breathless and has lost weight. His appetite is normal, his stools loose and offensive.

His mother, Barbara, who is 23 years old, is 12 weeks pregnant. She has two brothers, Ian and Steve, and a sister Margaret. Steve and Margaret are unmarried. Ian is married to Christine and they have a 3 year old daughter, Andrea. Barbara's parents are Douglas and Holly. Holly's sister, Carol, is the mother of Barbara's husband, Collin, who is 27 years old. There is no previous family history of CF.

On examination, William was pale, thin and finger clubbing was observed. A moist cough was heard. The chest showed good excrusions with no dullness to percussion over both lung fields. Cardiac exam was normal. The abdomen was soft and non-tender without organomegaly.

On investigation, the blood film was normal. The qualitative stool analysis for fat showed abnormal fat drops. The sweat test sodium and chloride concentrations were elevated, compared to the normal. The chest x-ray showed hyperinflation and bronchial wall thickening.

Instructions:

- Answer the following with the help of this case study.
- Students in pairs will be asked to give one set of answers to these questions.
- A large group discussion will be held next session on this case study.
- These answers will not be graded, and will not be a part of your assessment.

HGU Questions for LBC Students

Q1 From the description of William's condition, explain how the genetic defects lead to the clinical abnormalities described.

Q2 Describe the molecular genetic techniques used to detect mutation in CF syndrome. Discuss the variety of mutations found and their distribution in different population groups. Explain how mutation may lead to an alteration in the function of the CFTR protein.

Q3 Based upon the family history of William's case, answer the following questions:

a) Draw the pedigree chart, using standard symbols.

b) What is the pattern of transmission of CF, and what is the risk of CF for Barbara's next child?

c) How does the risk of CF in William's first cousin compare with the population risk 1/2000?

d) Which people in this pedigree are obligate heterozygotes?

HBD Objectives

The Objectives of this Human Biochemical Disorder (HBD) Unit are to enable the student:

1. To describe the DNA composition of chromosomes in terms of structure, replication process and arrangement.

2. To define the general structure and function of amino acids and the role of RNA components in protein synthesis.

3. To discuss the principles and methods of laboratory molecular genetics and its utilization in medicine.

4. To explain protein and amino acids analysis techniques and their main differences.

5. To describe the application of genetic engineering in medicine.

6. To construct a pedigree chart for a family.

7. To discuss the types of Mendelian inheritance in humans.

Potential Learning Issues

1. The DNA composition in chromosomes.

   a) The chemical composition and their structure.
   b) The Watson-Crick model of DNA.
   c) The model and mechanism of DNA replication.
   d) Chromosome structure from the level of DNA.

2. The structure and function of amino acids and role of RNA in protein synthesis.

   a) The transfer of genetic information from DNA to protein.
   b) The process of transcription and the messenger RNA (MRNA).
   c) The process of translation.
   d) The organisation of human genes.
   e) Transport protein: The haemoglobin model.

3. Explain mutation in the human genome.

   a) Types of mutation.
   b) Causes of mutation.
   c) Detection of mutation.
   d) Measuring mutation rates.
   e) The phenomenon of impaired genome and its role in the expression of genetic disorders.

4. The principles and methods of laboratory molecular genetics and its utilisation in medicine.

   a) The use of restriction enzymes and vectors.
   b) Polymerase Chain Reaction (PCR) analysis.
   c) Principles of electrophoresis.
   d) The use of hybridisation techniques.

5. The protein and amino acid analysis techniques.

   a) Southern blotting technique.
   b) Northern blotting technique.
   c) Western blotting technique.

6. The application of genetic engineering.

   a) DNA recombinant use.
   b) DNA fingerprint analysis.
   c) Gene therapy procedure.
   d) The procedure of genetic mapping.

7. Construction of a pedigree chart.

   a) Symbols used in pedigree.
   b) Analysis of pedigree.
   c) The significance of pedigree in medicine.

8. Discuss the type of genetics Mendelian inheritance and their types.

   a) The behaviour of autosomal recessive traits.
   b) The behaviour of autosomal dominant traits.
   c) The concept of codominance.

Problem Brief (PB)

The aim of this trigger is to understand the concepts of chromosomal disorders through a 15-year-old female, of short stature and obese, who was referred to the department of Gynaecology and Obstetrics with a primary amenorrhoea.

List the chromosomal disorder learning issues you plan to study in these three sessions.

Instructions:

- This sheet will be collected by the tutor assigned.
- Do not write your name or ID number on this page.

HUMAN CHROMOSOMAL DISORDER (HCD) PROBLEM

Part I

The Case History:

Fatimah, a 15-year-old female, was referred to the Gynaecological and Obstetrics Clinic from a local primary care centre because of primary amenorrhoea (her menstrual periods had not begun yet). She was short in stature and obese. She had been in good health and had had no previous serious illnesses.

She was born at term and weighed 2.8 kg. She is in intermediate school (8th grade) and doing very well there.

Part I (continued)

The Family History:

Fatimah's family structure consists of her parents, two brothers and one sister. Her mother, Huda, is 45 years old and her father is 47 years old. Fatimah is the youngest daughter and the fourth of her parents' children.

Both parents are in good health with no previous illnesses, although her father was admitted last year with a myocardial infarction. Her sister and brothers are all in good health and are doing reasonably well at school. In general, there is no history of genetic diseases in this family.

You may proceed to the clinical examination data.

Part II

The Clinical Examination Data:

The gynaecologist found the following during the clinical examination:

The vital signs:

	Fatimah	Normal Range
Temperature, °C	37.0	36.5 - 37.5
Pulse rate, beat/min	94	80-112
Blood pressure, mm/Hg	136/90	80-110/50-80
Respiration, per min	29	20-30

Also;

Weight, kg	80	(75th percentile)
Height, cm	1.40	(<5th percentile)

Compared to her parents:

	Father	Mother	Normal Range
Weight, kg	82	76	(≅ 50th percentile)
Height, cm	1.80	1.68	(≅ 50th percentile)

The physical examination:

She appeared obese, her chest was shield shaped, and she had widely-spaced nipples. No breast tissue could be palpated and she had webbing of the neck.

Cardiovascular system:

Absent femoral pulse (radio femural delay)

Abdomen:

No organomegaly.

The pelvic examination:

By bimanual palpation, the patient's uterus was small and her gonads could not be felt.

- *You may proceed to the laboratory test data.*

Part III

Laboratory Data:

The gynaecologist decided to order the following tests:

Haematological values:

	Fatimah	Normal Range
Haemoglobin (Hb) count, $10^{9/l}$	122	115-165
Haemotocrit (PCV), %	38	36-47
Reticulocytes, %	2.0	0.5-2.5
Erythrocytes (RBC), $10^{12/l}$	3.6	3.8-5.8
Mean Cell Volume (MCV), fl	84	77-95
Mean Cell Haemoglobin (MCH), pg	30	27-22
Mean Cell Haemoglobin Concentration (MCHC), g/dl	34	32-36
White blood cell (WBC) count, $10^{9/l}$	6.9	4.0-11.0
Neutrophils, $10^{9/l}$	2.15	2.0-7.5
Lymphocytes, $10^{9/l}$	2.2	1.5-4.5
Monocytes, $10^{9/l}$	0.6	0.2-0.8
Eosinophils, $10^{9/l}$	1.7	0.01-0.4
Basophils, $10^{9/l}$	0.25	0-0.1

The chemical pathology test data:

Total Bilurubin, mmol/l	18	<17
Total Protein, gr/l	65	63-80

Kidney function and electrolytes test:

Normal

Gonadotropin (FSH, LH)

FSH, IV/L	10.5	0.5-9.5
LH IV/L	15.6	3-12

Hearing assessment:

Normal

Part III (continued)

Intelligence Quotient (IQ):

	Fatimah	Normal Range
IQ	112	(111-117)

X-Rays:

Left wrist x-rays for bone age were interpreted as consistent with age 11 according to this equation (normal bone age = chronologic bone age ± 15 months)

The cytogenetic test:

The analysis of Fatima's chromosomes by scoring 100 cells from cultures of Fatima's white blood cells were found to have a 45, X,/46, X constitution.

The chromosomes of both her parents were indistinguishable from normal.

The DNA Test:

DNA from the family was tested with a variety of probes. Using the techniques of southern blotting, DNA prepared from Fatima's leukocytes was shown to hybridise with Y-specific DNA probes. Fluorescence in-situ hybridisation showed that the marker chromosome contained Y-specific DNA. There was a risk of approximately 25% of gonadal blastoma, a pre-malignant gonadal tumour.

Part IV

The Clinical Application:

The management protocol currently used for such condition is that the patient should be given growth hormones at the age of 5 years, and oestrogen hormone at 12 years to induce the sexual features.

However, on account of her age and not having taken the hormone, the doctor recommended the following for Fatima:

Psychological support that would raise her self-esteem and help her cope with the embarrassment about her condition. The gonads were to be removed surgically because they had increased incidence of gonal malignancy. The cardiologist was referred to for the treatment of hypertension and coarctation of the aorta.

[Thank you for your cooperation]

HUMAN CHROMOSOMAL DISORDER (HCD) PROBLEM FOR LBC STUDENTS

Mohammed (10 days) neonate male (3.4kg), was born at a primary health care centre in his region. He was referred to the paediatrics clinic with a diagnosis of Down's syndrome for further evaluation and counselling.

The mother of Mohammed is Maryam, who is 45 years old. She is reasonably healthy and there was no maternal illness during her pregnancy. His father is Saleh, who is 46 years old. He has no previous illnesses and is in good health. The parents are not related. Mohammed is the first child of the couple.

The geneticist in the clinic confirmed the clinical features Mohammed's condition. The characteristics are:

> The facial appearance led to a common clinical diagnosis. The palpebral fissures are upslanting, with brush field spots in the iris, the nose is small, facial profile flat and ears low set.
>
> Hypotonia marked and redundant folds of skin about the neck.
>
> The skull is brachycephalic.
>
> A single palmar crease, the little fingers are short and incurved (clinodactyly); there is also a wide gap between the first and second toes.

On examination, Mohammed's body temperature was 37°C, and his blood pressure 85/55. Cardiovascular examination was normal. The abdomen examination showed no abnormal distention.

On investigation; the routine haematology results were normal. Chest x-ray was normal. Cytogenetic analysis showed trisomy for chromosome 21.

<u>Instructions:</u>

- Answer the following with the aid of this case study.
- Students in pairs will be asked to complete one set of answers to the questions.
- A large group discussion will be held next session around the case study.
- These answers will <u>not</u> be graded, and will <u>not</u> be a part of your assessment.

HGU Questions for LBC Students

Q1 From the above observation for the condition.
What factors in Mohammed's family might be related to a risk of Down's syndrome?

Q2 What would be the risk of a second child born to these parents having Down's syndrome?

Q3 According to the chromosome laboratory test (cytogenetic report) it states that Mohammed's karyotype shows trisomy, 21 - (47,X9 + 21).

a) What does this karyotype mean?

b) The laboratory asks for blood samples from the clinically normal parents (Mohammed's parents). Why?

HCD Objectives

The Objectives of Human Chromosomal Disorder (HCD) Unit are to enable the student:

1. To describe the mechanism of mitosis and meiosis as a mechanism of cell growth and reproduction.

2. To provide details of the human chromosome and the karyotype in human genetics.

3. To explain the role of molecular cytogenetics in DNA diagnostics in medicine.

4. To explain the mechanism of non-disjunction in gamete formation and its effect in humans.

5. To discuss the autosomal trisomic condition and its risk factors.

6. To describe sex chromosome abnormalities and their effect on the phenotype.

7. To list the characteristic patterns of Mendelian X-linked inheritance.

8. To explain mutation in the human genome.

Potential Learning Issues

1. The mechanism of mitosis and meiosis.
   a) Chromosome behaviour in mitosis.
   b) Chromosome behaviour in meiosis.
   c) The significance of mitosis and the genetic control of the cell cycle.
   d) The process of meiosis and the formation of gametes.
   e) Draw a cell cycle.

2. Human chromosome set and the karyotype.
   a) The importance of numerical chromosome.
   b) The importance of chromosome structure variation, e.g. deletion and translocation.
   c) The preparation of karyotype.
   d) The analysis of karyotype.

3. The role of molecular cytogenetics on DNA diagnostics.
   a) Preparation of cytogenetics in a laboratory.
   b) Application of molecular cytogenetics.

4. The mechanism of non-disjunction in gamete formation.
   a) The process of non-disjunction.
   b) The effect of non-disjunction.

5. Autosomal trisomic condition.
   a) Define autosomal trisomic.
   b) Examples of trisomic disorder.
   c) The maternal age as a risk factor.

6. The sex chromosome abnormalities.
   a) The segregation of sex chromosome into gametes and male heterogametic sex chromosomes.
   b) The role of the 'Y' chromosome.
   c) The role of the 'X' chromosome.
   d) The syndromes associated with sex chromosomes.

7. The characteristic pattern of Mendelian inheritance of X-linked chromosomes.
   a) How Mendelian principles apply to this inheritance.
   b) The behaviour of X-linked dominant chromosomes.
   c) The behaviour of X-linked recessive chromosomes.

HUMAN MULTIFACTORIAL DISORDER (HMD) PROBLEM

Problem Brief (PB)

The aim of this trigger is to understand through clinical application the multi-factorial disorder in human genetics, through a 26-year-old female who collapsed at home. She was admitted to the emergency room.

List the multi-factorial disorder learning issues you plan to study in these sessions.

Instructions:

- This sheet will be collected by the tutor assigned.
- Do not write your name or ID number on this page.

HUMAN MULTIFACTORIAL DISORDER (HMD) PROBLEM

Problem Brief (PB)

The aim of this trigger is to understand through clinical application the multi-factorial disorder in human genetics, through a 26-year-old female who collapsed at home. She was admitted to the emergency room.

List the multi-factorial disorder learning issues you plan to study in these sessions.

Instructions:

- This sheet will be collected by the tutor assigned.
- Do not write your name or ID number on this page.

The Human Multifactorial Disorder (HMD)

Part I

The Case History:

Noora, a 26-year-old female was admitted unconscious to the emergency room at 8.30am. Her husband, Emad, who is 30 years old, brought her. He said that she had collapsed while working at home that morning. She is a housewife. She has a 3-year-old child and is expecting her second.

A routine blood test was ordered immediately. At the scene, the emergency medical doctor noticed her blood glucose was about 2.8 m mol (normal 3.8-5.8). She was immediately given an intravenous injection of 50% dextrose.

She regained consciousness shortly after her arrival at hospital. She was perspiring profusely and was cold and clammy even though her temperature was 36°C. She complained of feeling weak, and of a tingling feeling in her legs.

The resident on call in the internal medicine department began an I.V. of 10% dextrose.

By 12.30pm, Noora, was feeling better. When questioned about what had happened, she indicated that she had been in a hurry that morning to finish the housework before lunch time, and had only a piece of pitta bread and a cup of tea for breakfast.

She is well known as a diabetic patient, diagnosed two years earlier. She had been taking two injections of lente insulin. She said that she had had a fainting spell the previous month, and had also noticed that she had lately been losing weight. She had had no previous admissions.

Part I (continued)

The Family History:

Her husband, Emad, is quite healthy with no previous illnesses. Her 3-year-old son is also in good health. Her father, Faihan, who is 55 years old, has a history of insulin-dependent diabetes mellitus; her mother, Husa, who is 50 years old, is obese with a hypertension history. Her grandfather died 5 years ago. He had had a long history of diabetes.

- *You may proceed to the clinical examination data.*

Part II

Clinical Examination Data:

The Physician on call decided to have a full clinical investigation.

The vital signs:

	Noora	Normal Range
Temperature, °C	36	36.5-37.5
Pulse rate, beat/min	120	80-112
Blood pressure, mm/Hg	120/60	80-110/50-80
Respiration rate/min	30	20-30

Also:

Weight, kg	55	(10th percentile)
Height, cm	1.70	(≅50th percentile)

The physical examination:

She looks thin and pale.
She was 16 weeks pregnant when seen.

Cardiovascular system:

Normal

Foetal heartbeat:

Normal

Abdomen:

No organomegaly

Neurological examination:

Normal

- *You may proceed to the laboratory test data.*

Part III

Laboratory Data:

The Physician decided to order the following test:

Haematological values:

	Noora	Normal Range
Haemoglobin (Hb) count, $^{9/1}$	130	115-165
Haemotocrit (PCV), %	40	36-47
Reticulocytes, %	0.90	0.5-2.5
Erythrocytes (RBC), $^{10\ 12/l}$	5.7	3.8-5.8
Mean cell volume (MCV), fl	87.0	77-95
Mean cell Haemoglobin (MCH), pg	31	27-32
Mean cell Haemoglobin concentration (MCHC), g/dl	33	32-36
White blood cell (WBC) count, 10 $^{9/1}$	9.0	4.0-11.0
Neutrophils, 10 $^{9/1}$	5.8	2.0-7.5
Lymphocytes, 10 $^{9/1}$	2.0	1.5-4.5
Monocytes, 10 $^{9/1}$	0.5	0.2-0.8
Eosinophils, 10 $^{9/1}$	0.2	0.04-0.4
Basophils, 10 $^{9/1}$	0.5	0-0.1
Platelets count, 10 $^{9/1}$	260	140-400

Chemical pathology test data:

Sodium (Na+), mmol/l	136	135-145
Potassium (K+),mmol/l	3.9	3.5-5.0
Bicarbonate (Hco_3), mmol/l	26	24-31
Urea, mmol/l	6.0	3.0-6.5
Creatinine, umol/l	85	60-125
Albumin, 10 $^{9/1}$	42	32-50
Total protein,10 $^{9/1}$	76	63-80

Office blood value:

Blood Glucose, mmol/l	11	4-6 (fasting)

Part III (continued)

Urine glucose analysis using dip stick:

Glucose	+2	(Normal no glucose in urine)
Ketoses	negative	(no ketones)

PH and arterial blood gas:

	Noora	Normal Range
PH	7.40	7.36-7.45
PO2, mm/Hg	95	75-100
PCO2, mm/Hg	35	35-45

Ultrasound for foetus:

Normal

Part IV

The Clinical Application:

The Physician on call decided to admit her in to hospital to monitor her overnight. The next day she continued to get better.

The Physician advised her that she needed to carefully regulate the intake of lente insulin, which is one injection of 20 units per day. Also, he recommended that she alternate the sites of the injections between her abdomen, thigh and deltoid areas. He encouraged her to monitor her blood glucose level twice a day (overnight fasting and pre dinner) using a portable glucose meter.

The doctor emphasized regular food intake and exercise to avoid further episodes of hypoglycaemia. She was encouraged to keep in touch with her primary care physician at the local centre.

[Thank you for your co-operation]

<u>**HMD Objectives**</u>

The Objectives of the Human Multifactorial Disorder (HMD) Unit are to enable the student to:

1. Explain the Mendelian inheritance and the difference between autosomal recessive, autosomal dominant, co-dominance and X-linked.

2. List the common multifactorial disorders in genetics.

3. Discuss the environment agent in causing multifactorial disorder.

4. Construct a pedigree pattern for a family with a particular multifactorial disorder.

5. Explain the role of cytogenetics in DNA diagnostics within medicine.

Potential Learning Issues:

1. The Mendelian inheritance and the difference between autosomal recessive, autosomal dominant, co-dominant and X-linked.

   a) Mendelian principles related to the medicine.
   b) The behaviour of the chromosome in each condition.
   c) The disease involved in each condition and its etiology.

2. The common multifactorial disorders in genetics.

   a) The features of each kind.
   b) The clinical and laboratory characteristics.
   c) The etiology of each type.
   d) The precautions that can be taken for each incidence in terms of preventative, counselling and medical ethics.

3. The role of environmental agents in causing genetic diseases.

   a) The significance of the environment/genetics.
   b) The interaction of genetics and the environment.
   c) The need to reduce the risk environment factors in people's lives.

4. Construct a pedigree pattern.

   a) Symbols used and analysis of pedigree.
   b) The significance of pedigree in medicine.

5. The role of cytogenetics in medicine.

   a) Chromosome set.
   b) Preparation and analysis of karyotype.
   c) The application of cytogenetics.

APPENDIX C

TUTOR TRAINING DEVELOPMENT MATERIALS

- Tutor Training Development Programme for HGU in PBL
- Letter to PBL Tutor
- Letter to LBC Tutor
- PBL Tutorial Process Guidelines for Tutors
- LBC Tutor Activity Schedule
- PBL Tutor Activity Schedule
- Student Learning Objective Sheet (SLOS)
- Student Suggested Clinical Plan (SSCP)
- References

TUTOR TRAINING DEVELOPMENT PROGRAMME FOR HUMAN GENETICS UNIT (HGU) IN PROBLEM-BASED LEARNING

⇒ Session 1

8.00 - 8.20	Welcome Coffee
8.20 - 8.30	Dean's Welcome
8.30 - 9.00	The researcher's address: • **PBL and HGU in Medical Education Research**
9.00 - 10.30	Seminars on: • **Overview of PBL** • **The Philosophy of PBL** • **The Rationale of PBL** • **The Process of PBL** • **The Glossary of PBL**
10.30 - 10.45	Break
10.45 - 11.15	Film (DVD): The Tutorial Process in PBL Part 1 (30 minutes) Howard Barrows and Ann Kelson (2000). University of Southern Illinois, U.S.A.
11.15 - 11.45	Group Discussion
11.45 - 1.00	Prayer and Lunch

⇒ Session II

1.00 - 2.30	Seminars on: • **Taxonomy of PBL** • **Tutorial process in PBL** • **Tutor roles and function** • **Small group process in PBL**
2.30 - 2.45	Break
2.45 - 3.15	Film (DVD): The Tutorial Process in PBL Part II (30 minutes) Howard Barrows and Ann Kelson (2000). University of Southern Illinois, U.S.A.
3.15 - 3.30	Group Discussion

3.30 - 4.30	Practice Session
4.00 - 5.00	Group discussion

⇒ Session III

8.00 - 8.30	Welcome Coffee
8.30 - 9.00	The researcher's address: • **The HGU goals and objectives.** • **The research purpose.** • **Conceptual approach.**
9.00 - 10.30	Seminars on: Overview of HGU Curriculum: • **Human Biochemical Disorder (HBD) problem cases.** • **Human Chromosomal Disorder (HCD) problem cases.** • **Genetics Unit Examination**
10.30 - 10.45	Break
10.45 - 11.45	Simulated tutorial session (group of undergraduate medical students)
11.45 - 12.10	Film (DVD): A pale young man: Problem-Based Learning in the tutorial group: An example of Internal Medicine (25 minutes). W. De Grave (1997). Faculty of Medicine, Maastricht University
11.45 - 1.00	Prayer and lunch

⇒ Session IV

1.00 - 2.30	Overview of Tutor work plan • **PBL tutorial process guideline for tutor** • **Tutor activity schedule** • **Student learning objective sheet (SLOS)** • **Student suggested clinical plan (SSCP)**
2.30 - 2.45	Break

2.45 - 4.00	Instruments involved in this research • **Tutor/Instructor Journal (TIJ)** • **Cognitive behaviour survey (CBS)** • **Student attitude survey (AS)** • **Course evaluation form (CEF)**
4.00 - 4.30	Film (DVD): Evaluation in the tutorial group: What now, tutor? (30 minutes). W. De Grave, E. Huismans, M. Luth & W.J. Beyen (2003). Faculty of Medicine, Maastricht University
4.30 - 4.40	Tutor training evaluation
4.40 - 5.00	Group discussion

[Thank you for your cooperation]

AHMED A. AL-KUWAITI
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Dear PBL Tutor

Thank you for your cooperation with regard to your participation in this research. You have been assigned to tutor a group of pre-clinical/clinical students to use the problem based learning approach. The Human Genetics study will be held this summer. You will meet Group (#) ____________, in room (#) ___________. You will be within this group for all the next three class sessions.

This study is very important to the Saudi medical education for two reasons. **First**, it is of direct relevance to the development of the curriculum of the Medical College, not just because Human Genetics is increasingly playing a greater role in understanding disease and its treatment, but also because the study investigates an innovative approach to undergraduate medical teaching. If this teaching is shown to be successful through this research project, it could help the Medical College provide a highly relevant and effective curriculum for its students and for the health care system in the country. **The second** reason that this is an important study is that it hopes to carry out research which will be of great interest and benefit throughout the world to people who are attempting to introduce this kind of teaching in their own medical schools and colleges.

Wishing you good luck and thanking you again.

Yours faithfully,

Ahmed A. Al-Kuwaiti

AHMED A. AL-KUWAITI

E-mail: a.a.al-kuwaiti@durham.ac.uk

Dear LBC Tutor

Thank you for your cooperation with regard to your participation in this research. You have been assigned to teach the Human Genetics Unit by using a specific approach, which involves a lecture accompanied by a case study and questions regarding the specific topic you will be assigned. You will meet the student volunteer for this research in room (#) ________________.

This study is very important to the Saudi medical education for two reasons. **First**, it is of direct relevance to the development of the curriculum of the Medical College, not just because Human Genetics is increasingly playing a greater role in understanding disease and its treatment, but also because the study investigates an innovative approach to undergraduate medical teaching. If this teaching is shown to be successful through this research project, it could help the Medical College provide a highly relevant and effective curriculum for its students and for the health care system in the country. **The second** reason that this is an important study is that it hopes to carry out research which will be of great interest and benefit throughout the world to people who are attempting to introduce this kind of teaching in their own medical schools and colleges.

Wishing you good luck and thanking you again.

Yours faithfully,

Ahmed A. Al-Kuwaiti

PBL TUTORIAL PROCESS GUIDELINES FOR TUTORS

Introduction:

The problem-based learning (**PBL**) tutor is a faculty member who guides a tutorial group in order to facilitate this educational process. The tutor has two major tasks:

a) To stimulate the learning process
b) To supervise the tutorial group's method of working and enhance the cooperation between students.

A brief guideline of the process is described below:

I) First Tutorial Group Meeting

Instructions:

A. Student members may report their names and background to others in the group.

B. Discuss ground rules for the group, for example there may be the need to enforce the rule of allowing each other to talk freely without the fear of criticism.

C. Ask two students to volunteer: one to act as a *discussion teacher* to ensure the procedure is systematic and to monitor the group process; the other to be a *minutes secretary* to take down whatever is said in the group, in order to avoid the loss of information. A blackboard and a note sheet for recording.

D. Hand out the *problem brief and* allow time for the students to read it. Record what they would like to learn (learning objectives) from this problem.

E. Pass out the *problem task*, let students read it by themselves and then start to apply the seven step ("seven jumps") approach (Schmidt, 1983).

⇒ **The Seven Step Approach ("Seven Jump"):**

Step 1: To clarify and define the terms and concepts which are not clear in the context of the problem.

Students may bring in medical dictionaries and other resources to use in class if they wish.

Step 2: To explain the problems arising where students explore the unrelated phenomenon in context. They may also divide the problem into sub-problems which can be discussed in a specific order.

This step is to direct the brain-storming process, in order to motivate further discussion of the problem.

Step 3: To analyse the problem which the students discuss; to think about the various possibilities which underlie the process and also the mechanisms within the problem.

Students continue this process, scanning for new information and creating new hypotheses.

This step is to activate prior knowledge and a basis for further discussion.

The tutor plays the role of evaluating and managing the problem, according to the knowledge and skills previously learned by students.

Step 4: To sort out the best hypothesis. By critically analysing the hypotheses, the ideas that have been previously generated can be prioritised. Various explanations are evaluated.

This step is to activate existing knowledge.

Step 5: To generate learning objectives:
The hypotheses that the student identifies during the analysis of the problem should enable a better understanding during this step. These learning objectives are carried out as a learning activity by the group and assigned for independent study.

This step is to direct the learning process for students.

The *minutes secretary* will record the learning objectives on the Student Learning Objective Sheet (SLOS). The tutor will hand it to the researcher at the end of the session.

II) Second tutorial group meeting

Step 6: Consists of self-directed learning, during which individual students implement step 5 learning objectives and look through both audiovisual resources and books, or consult a faculty member.

This step is to help the student gather relevant information, and gain the ability to understand the subject matter.

Students may decide to work together or as individuals, but there is no formal meeting.

III) Third tutorial group meeting.

Step 7: To report the self-directed study activities which conform to the learning objectives that the students discussed as a result of their self study.

Students should provide the group with this information orally and through hand-outs (if necessary).

Tutors should manage each student's presentation to make them time effective.

This step is to identify and discuss the uncertainty in the subject matter studied. It should also broaden the individual student's knowledge through exchange of information among group members.

Students may spend more time on the issues embedded in the problem rather than on solving it.

Students may suggest a clinical treatment plan for a problem. The *minutes secretary* will record the information on a Student Suggestions Clinical Plan (SSCP) and hand it to the tutor.

At the end of the session, the tutor will provide students with the treatment plan (Clinical Application section) used in the hospital. He will then encourage them to compare their plans and carry on the discussion.

LBC TUTOR ACTIVITY SCHEDULE

Date: ____________________ University: ____________________

Tutor: ____________________ Group: ____________________
(#)

Problem about: ____________________
(HBD/HCD)

Prerequisites:

- For lecture-based case preclinical students.
- Students should have finished pre-test in cognitive behaviour survey (CBS) and attitude survey for enrolment in this research.

First Class Meeting

- Lecture (120 minutes) about **Human Biochemical Disorder (HBD)**

Second Class Meeting

- Lecture (first 40 minutes) about Human Biochemical Disorder (HBD).
- Divide students into pairs and assign the case study questions.
- Provide students with Demographic Questionnaires.

Third Class Meeting

- Large group discussion focused on student answers to the questions.

Fourth Class Meeting

- Lecture (first 40 minutes) about **Human Chromosomal Disorder (HCD).**

Fifth Class Meeting

- Lecture (first 40 minutes) about Human Chromosomal Disorder (HCD).

Sixth Class Meeting

- Large group discussion focused on student answers to the questions.
- Provide the researcher with tutor journal form (TJF).
- Provide students with the following:
  Post-test Cognitive Behaviour survey.
  Post-test Attitude survey.
  Student evaluation.

PBL TUTOR ACTIVITY SCHEDULE

Date: ______________________ University: ______________________

Tutor: ______________________ Group: ______________________ (#)

Problem about: ______________________ (HBD/HCD)

<u>Direction:</u>

- This is <u>only</u> for closed-loop problem based learning students.
- Students should have finished pre-test in cognitive behaviour survey (CBS) and attitude survey (AS), in order to be enrolled in this research.

<u>First Tutorial Group Meeting</u>

- Discuss the PBL tutorial process guideline.
- Provide students with the following:
    - ♦ Human Biochemical Disorder (HBD) problem brief sheet
    - ♦ Human Biochemical Disorder (HBD) Part I (History case)
    - ♦ Human Biochemical Disorder (HBD) Part II, III (Clinical Examination/data/laboratory Test data)
- Provide the researcher with the following:
    - ♦ HBD problem brief sheet

<u>Second Tutorial Group Meeting</u>

- Self-directed meeting.
- No formal meeting.
- Provide the student with Demographic Questionnaire.

Third Tutorial Group Meeting

- Provide the student with HBD Part IVB (clinical application)
- Provide the researcher with the following:
  - ♦ Student learning objective sheet (SLOS)
  - ♦ Student suggested clinical plan (SSCP)

Fourth Tutorial Group Meeting

- Provide students with the following:
  - ♦ Human chromosomal Disorder (HCD) problem brief sheet.
  - ♦ Human chromosomal Disorder (HCD) Part I (case history)
  - ♦ Human chromosomal Disorder (HCD) Part II, III (clinical examination/laboratory test data)
- Provide the researcher with the following:
  - ♦ HBD problem brief sheet

Fifth Tutorial Group Meeting

- Self-directed meeting
- No formal meeting

Sixth Tutorial Group Meeting

Provide students with the following:

- ♦ Part IV (clinical application)
- ♦ Post test cognitive behaviour survey
- ♦ Post test student attitude
- ♦ Student evaluation

Provide the researcher with the following:

- ♦ Student learning objective sheet (SLOS)
- ♦ Student suggested clinical plan (SSCP)
- ♦ Tutor Journal Form

STUDENT LEARNING OBJECTIVES SHEET (SLOS)

Date: ______________________________ University: ______________________________

Tutor: ______________________________ Group: ______________________________ (#)

Undergraduate student: ______________________________
(preclinical/clinical)

A problem about: ______________________________
(HBD/HCD/HMD)

Students agreed to carry out the following learning objectives as a learning activity:

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
9. ____
10. ____

NOTES:

____

____

____

STUDENT SUGGESTED CLINICAL PLAN (SSCP)

Date: ______________________________ University: ____________________________

Tutor: ______________________________ Group: ______________________________ (#)

Undergraduate student: ____________________________________
(pre-clinical/clinical)

A problem about: ____________________________________
(HBD/HCD/HMD)

Student suggested the clinical treatment plan as follows:

NOTES:

____

____

____

APPENDIX D

STUDENT DEVELOPMENT MATERIALS

- Letter to PBL and LBC students

- PBL Tutorial Process Guidelines for Students

- LBC Tutorial Process Guidelines for Students

AHMED A. AL-KUWAITI
E-mail: a.a.al-kuwaiti@durham.ac.uk

Dear Student

Thank you for your cooperation and participation in this research. You have been randomly assigned to testify to a specific approach in medical education for studying Human Genetics. You will meet Group (#) _______________ in room (#)_____________. You will be studying within this group for all of the next three class sessions.

Using this approach may appear different at the beginning, but with your kindness, effort and practice as well as the tutor's assistance, the process will become much easier and understandable.

This study is very important to the Saudi medical education for two reasons. **First**, it is of direct relevance to the development of the curriculum of the Medical College, not just because Human Genetics is playing an increasing role in the understanding of disease and its treatment, but also because the study investigates an innovative approach to undergraduate medical teaching. If this approach is found to be successful through this research project, it could help the Medical College provide a highly effective curriculum for its students and for the health care system in the country. **The second** reason that this is an important study is that it carries out research which will be of great interest and benefit throughout the world to people who are attempting to introduce this kind of teaching in their own medical schools and colleges.

Wishing you good luck and thanking you again.

Yours faithfully

Ahmed A. Al-Kuwaiti

PBL TUTORIAL PROCESS GUIDELINES FOR STUDENTS

I) First Tutorial Group Meeting

Instructions:

A. Student members may report their names and background to the others.

B. Discuss ground rules for the group; for example, you may need to ensure that every participant is allowed to talk without inhibition and fear of criticism from peers.

C. Two students will volunteer: one student will act as a *discussion teacher* to ensure maintenance of educational systematic procedure and to monitor the group process, and the other will be a *minutes secretary* to take down the discussion in the group, in order to avoid the loss of information. A blackboard and a note sheet may be used for the purpose.

D. Students will receive the *problem brief* for perusal. They may record what they would like to learn (learning objectives) from this problem.

E. Students will receive the *problem task*, read it individually and apply the seven step ("seven jumps") approach (Schmidt, 1983).

⇒ The Seven Step Approach ("Seven Jump"):

Step 1: To clarify and define the terms and concepts which are not clear in the context of the problem.

Students may bring in medical dictionaries and other resources to use in class if they desire.

Step 2: To explain the problems arising where students explore the unrelated phenomenon in context. The problem may also be divided into sub-problems which can be discussed in a specific order.

This step is to direct the brain-storming process and further discussion of the problem.

Step 3: To analyse and discuss the problem with other students, and think about the various possibilities underlying the process as well as the mechanisms within the problem.

Students continue this process, scanning for new information and creating new hypotheses.

This step is to activate prior knowledge and acts as a basis for further discussion.

Step 4: To sort out the best hypothesis. By critically analysing the hypotheses, the ideas that have been previously generated can be prioritised. The different explanations can be evaluated.

This step is to activate existing knowledge.

Step 5: To generate learning objectives:
The hypotheses that the student identifies during the analysis of the problem should enable a better understanding during this step. These learning objectives are carried out as a learning activity by the group and assigned for independent study.

This step is to direct the learning process for students.

The *minutes secretary* will record the learning objectives on the Student Learning Objective Sheet (SLOS), to be handed in to the researcher at the end of the session by the tutor.

II) Second tutorial group meeting

Step 6: Self-directed learning, during which individual students carry out the step 5 learning objectives and look through both audiovisual resources and books or consult a faculty member.

To assist independent study, literature and audiovisual resources specific to the problem being studied have been reserved for HGU in the University Library.

This step is to help the student to gather relevant information, and gain the ability to assimilate the subject matter.

Students may decide to work together or as individuals, but there is no formal meeting.

III) Third tutorial group meeting.

Step 7: To report the self-directed study activities which conform to the learning objectives discussed by the students as a result of their self study.

Students should provide the group with this information orally and through hand outs (if necessary).

This step is to identify and discuss the uncertainty in the subject matter studied. Also, this broadens the students' knowledge through the exchange of information.

Students may spend more time on the issues embedded in the problem rather than on solving it.

Students may suggest a clinical treatment plan for a problem. The *minutes secretary* will record the information on a Student Suggestions Clinical Plan (SSCP) and hand it to the tutor.

At the end of the session, the tutor will provide students with the treatment plan (Clinical Application section) used in the hospital. He will then encourage them to compare their plans and discuss.

[Thank you for your cooperation]

LBC TUTORIAL PROCESS GUIDELINES FOR STUDENTS

I) First Class Meeting

This meeting is devoted completely to a specific Human Genetics, HBD/HCD lecture (120 minutes).

II) Second Class Meeting

The first 40 minutes, Instructor continues lecturing. The rest of the time, students will divide into pairs to study the case and answer questions.

III) Third Class Meeting

This meeting is devoted to a large group which focuses on the students' answers to the questions set in the second class meeting.

[Thank you for your cooperation]

LBC TUTORIAL PROCESS GUIDELINES FOR STUDENTS

I) First Class Meeting

This meeting is devoted completely to a specific Human Genetics, HBD/HCD lecture (120 minutes).

II) Second Class Meeting

The first 40 minutes, Instructor continues lecturing. The rest of the time, students will divide into pairs to study the case and answer questions.

III) Third Class Meeting

This meeting is devoted to a large group which focuses on the students' answers to the questions set in the second class meeting.

[Thank you for your cooperation]

APPENDIX E

- Pre-test Analysis

Pre data comparison of teaching methods (LBC and PBL) across subscales for pre-clinical students

Variables	Method of Teaching	Mean	Std. Deviation	t Statistics	Mean Difference	p-value
Fulfil Knowledge Requirement	LBC	0.19	0.93	0.10	-0.01	0.92
	PBL	0.18	0.93			
Problem Solving and Critical Thinking Skills	LBC	0.17	0.76	-0.06	0.01	0.96
	PBL	0.17	0.80			
Knowledge Retention (Reflection)	LBC	0.21	0.83	0.29	-0.03	0.78
	PBL	0.18	0.87			
Motivation	LBC	0.18	0.89	0.41	-0.05	0.68
	PBL	0.13	0.96			
Self Directed Skills	LBC	0.21	0.79	0.27	-0.03	0.79
	PBL	0.18	0.82			
Level of Preparation	LBC	0.10	0.81	0.17	-0.02	0.87
	PBL	0.09	0.82			
Learning About Medicine	LBC	0.42	1.13	0.10	-0.01	0.92
	PBL	0.40	1.11			
Working with Patients	LBC	0.42	1.20	0.16	-0.03	0.87
	PBL	0.40	1.20			
Career Focusing on Medicine	LBC	0.13	0.87	0.41	-0.05	0.68
	PBL	0.09	0.89			
Problems Associated With Medicine	LBC	0.42	1.12	0.12	-0.02	0.90
	PBL	0.41	1.12			
Learning Experience	LBC	0.13	0.83	0.01	0.00	1.00
	PBL	0.13	0.83			
Resources of Information	LBC	-0.21	0.97	-0.08	0.01	0.94
	PBL	-0.20	0.97			
Tutors' Perception of Learning Method	LBC	-0.18	1.28	-0.55	0.27	0.59
	PBL	0.09	0.80			

Pre data pre-clinical LBC and PBL students' mean scores

		Method of Teaching								
		LBC		PBL		Mean Difference				Std Error
Scales	Variables	Mean	Std Deviation	Mean	Std Deviation	PBL-LBC	P-value	Pooled Std Deviation	Effect size	Effect size
Cognitive Behavior Survey (CBS)	Fulfil Knowledge Requirement	0.19	0.93	0.18	0.93	-0.01	0.92	0.93	-0.01	0.13
	Problem Solving and Critical thinking Skills	0.17	0.76	0.17	0.80	0.01	0.96	0.78	0.01	0.13
	Knowledge Retention (Reflection)	0.21	0.83	0.18	0.87	-0.03	0.78	0.85	-0.04	0.13
	Motivation	0.18	0.89	0.13	0.96	-0.05	0.68	0.93	-0.05	0.13
	Self Directed Skills	0.21	0.79	0.18	0.82	-0.03	0.79	0.81	-0.04	0.13
	Level of Preparation	0.10	0.81	0.09	0.82	-0.02	0.87	0.81	-0.02	0.13
Attitude Survey (AS)	Learning About Medicine	0.42	1.13	0.40	1.11	-0.01	0.92	1.12	-0.01	0.13
	Working with Patients	0.42	1.20	0.40	1.20	-0.03	0.87	1.20	-0.02	0.13
	Career Focusing on Medicine	0.13	0.87	0.09	0.89	-0.05	0.68	0.88	-0.06	0.13
	Problems Associated With Medicine	0.42	1.12	0.41	1.12	-0.02	0.90	1.12	-0.02	0.13
Demographic Survey (DQ)	Learning Experience	0.13	0.83	0.13	0.83	0.00	0.99	0.83	0.00	0.13
Tutor Journal Form (TEF)	Resources of Information	-0.21	0.97	-0.20	0.97	0.01	0.94	0.97	0.01	0.13
	Tutors' Perception of Learning Method	-0.18	1.28	0.09	0.80	0.27	0.59	1.07	0.26	0.47

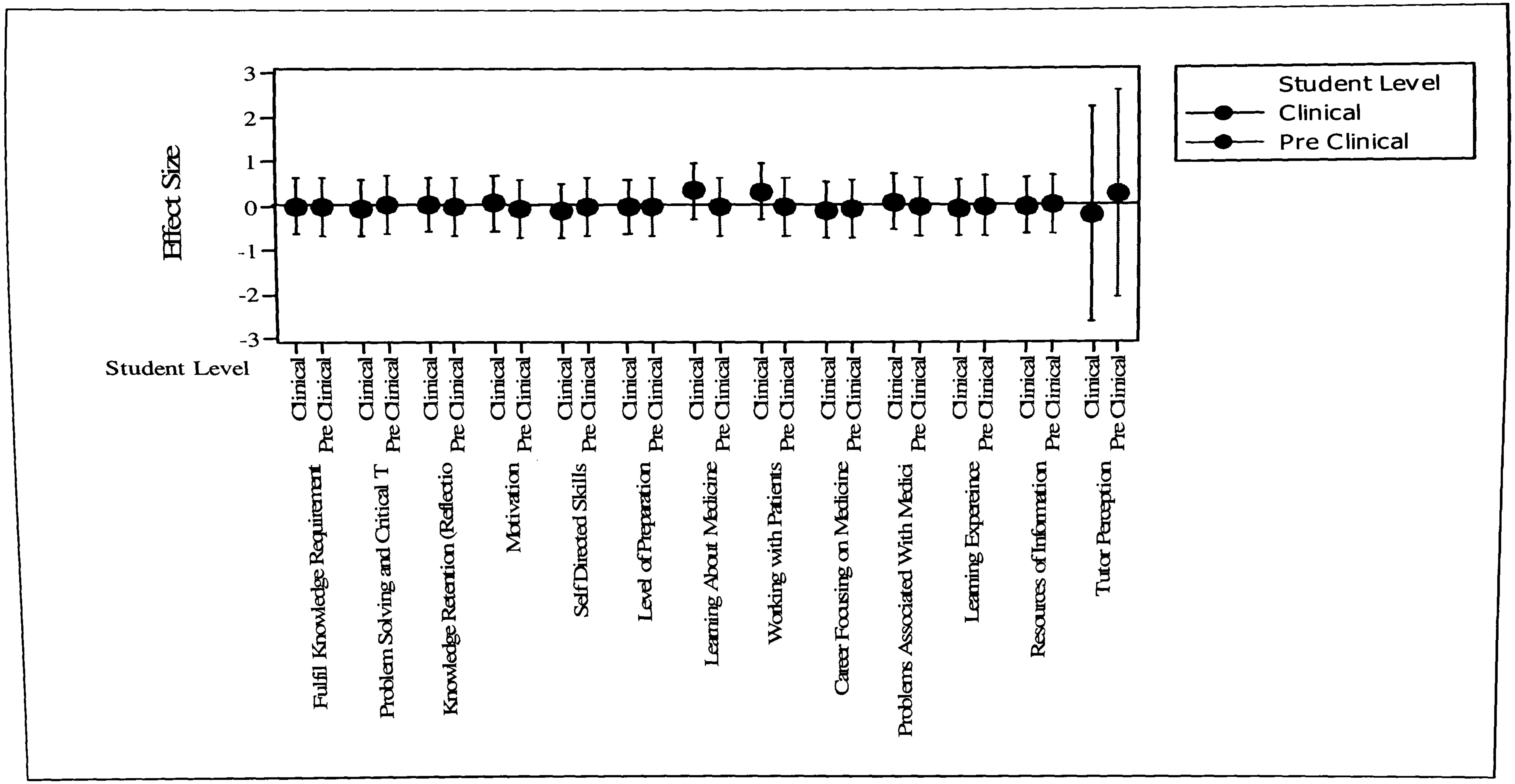
Pre data comparison of teaching methods (LBC and PBL) across subscales for clinical students

Variables	Method of Teaching	Mean	Std. Deviation	t Statistics	Mean Difference	p-value
	LBC	0.06	0.99			
Fulfil Knowledge Requirement	PBL	0.06	1.02	0.03	0.00	0.98
	LBC	0.07	0.83			
Problem Solving and Critical Thinking Skills	PBL	0.02	0.93	0.47	-0.05	0.64
	LBC	0.08	0.91			
Knowledge Retention (Reflection)	PBL	0.10	0.88	-0.21	0.02	0.83
	LBC	0.08	0.88			
Motivation	PBL	0.13	0.90	-0.44	0.05	0.66
	LBC	0.13	0.89			
Self Directed Skills	PBL	0.02	0.91	0.94	-0.11	0.35
	LBC	-0.02	0.87			
Level of Preparation	PBL	-0.04	0.94	0.16	-0.02	0.87
	LBC	0.23	1.25			
Learning About Medicine	PBL	0.58	0.85	-2.64	0.36	0.01
	LBC	0.21	1.32			
Working with Patients	PBL	0.56	0.94	-2.42	0.35	0.02
	LBC	0.04	0.89			
Career Focusing on Medicine	PBL	-0.07	1.04	0.88	-0.11	0.38
	LBC	0.25	1.21			
Problems Associated With Medicine	PBL	0.33	1.07	-0.59	0.08	0.56
	LBC	0.02	0.89			
Learning Experience	PBL	-0.03	0.95	0.39	-0.04	0.70
	LBC	-0.16	0.95			
Resources of Information	PBL	-0.18	1.01	0.15	-0.02	0.88
	LBC	0.15	1.20			
Tutors' Perception of Learning Method	PBL	-0.07	0.89	0.48	-0.21	0.63

Pre data clinical LBC and PBL students' mean scores

		Method of Teaching								
		LBC		PBL		Mean Difference				Std Error
Scales	Variables	Mean	Std Deviation	Mean	Std Deviation	PBL-LBC	P-value	Pooled Std Deviation	Effect size	Effect size
Cognitive Behavior Survey (CBS)	Fulfil Knowledge Requirement	0.06	0.99	0.06	1.02	0.00	0.98	1.01	0.00	0.13
	Problem Solving and Critical thinking Skills	0.07	0.83	0.02	0.93	-0.05	0.64	0.88	-0.06	0.13
	Knowledge Retention (Reflection)	0.08	0.91	0.10	0.88	0.02	0.83	0.90	0.03	0.13
	Motivation	0.08	0.88	0.13	0.90	0.05	0.66	0.89	0.06	0.13
	Self Directed Skills	0.13	0.89	0.02	0.91	-0.11	0.35	0.90	-0.12	0.13
	Level of Preparation	-0.02	0.87	-0.04	0.94	-0.02	0.87	0.91	-0.02	0.13
Attitude Survey (AS)	Learning About Medicine	0.23	1.25	0.58	0.85	0.36	0.01	1.07	0.33	0.13
	Working with Patients	0.21	1.32	0.56	0.94	0.35	0.02	1.14	0.31	0.13
	Career Focusing on Medicine	0.04	0.89	-0.07	1.04	-0.11	0.38	0.97	-0.11	0.13
	Problems Associated With Medicine	0.25	1.21	0.33	1.07	0.08	0.56	1.14	0.07	0.13
Demographic Survey (DQ)	Learning Experience	0.02	0.89	-0.03	0.95	-0.04	0.70	0.92	-0.05	0.13
Tutor Journal Form (TEF)	Resources of Information	-0.16	0.95	-0.18	1.01	-0.02	0.88	0.98	-0.02	0.13
	Tutors' Perception of Learning Method	0.15	1.20	-0.07	0.89	-0.21	0.63	1.06	-0.20	0.49

Pre data effect sizes with 95% CIs for pre-clinical and clinical students and tutors



APPENDIX F

- Durham University Ethics Committee permission letter

Durham University
School of Education

Shaped by the past, creating the future

1 June 2006

Mr Abdullah M Al-Nasser
Cultural Attaché
Royal Embassy of Saudi Arabia
29-32 Belgrave Square
London
SW1X 8QB

Dear Mr. Al-Nasser

Ethical approval: Mr. Ahmed A. Al-Kuwaiti

I am pleased to inform you that the Ethics Committee of the School of Education has now approved Mr. Al-Kuwaiti's application for ethical approval in respect of 'Evaluating the Impact of Problem-Based Learning Curriculum through undergraduate medical students in Saudi Arabia'.

The Committee would like to take this opportunity to wish him all the very best with his research.

Yours sincerely

Dr. M. Fleming
Director of Research

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